



KENTUCKY TRANSPORTATION CENTER

**A NEEDS ASSESSMENT AND TECHNOLOGY EVALUATION FOR
ROADSIDE IDENTIFICATION OF COMMERCIAL VEHICLES**



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**A NEEDS ASSESSMENT AND TECHNOLOGY EVALUATION FOR
ROADSIDE IDENTIFICATION OF COMMERCIAL VEHICLES**

by

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LIST OF ACRONYMS

AVI	Automatic Vehicle Identification
CVO	Commercial Vehicle Operations
CVSA	Commercial Vehicle Safety Alliance
DSRC	Dedicated Short-range Communications
DUNS	Dun and Bradstreet
ETC	Electronic Toll Collection
FARS	Fatal Accident Reporting System
FEIN	Federal Employer Identification Number
FHWA	Federal Highway Administration
GPS	Global Positioning Systems
IR	Infrared
ITS	Intelligent Transportation Systems
IFTA	International Fuel Tax Agreement
IRP	International Registration Plan
ICC	Interstate Commerce Commission
ISS	Inspection Selection System
ITDS	International Trade Data System
JHU/APL	The Johns Hopkins University Applied Physics Laboratory
KYU	Kentucky Unit
LPR	License Plate Reader
MCMIS	Motor Carrier Management Information System
MCSAP	Motor Carrier Safety Assistance Program
NHTSA	National Highway Traffic Safety Administration
NLETS	National Law Enforcement Telecommunications System
NMVTIS	National Motor Vehicle Title Information System
OMCHS	Office of Motor Carrier and Highway Safety
OCR	Optical Character Recognition
PRISM	Performance and Registration Information Systems Management
RFID	Radio Frequency Identification

RFI	Request for Information
SAFER	Safety and Fitness Electronic Records
SAIC	Science Applications International Corporation
USDOT	United States Department of Transportation
VIN	Vehicle Identification Number
WIM	Weigh-In-Motion

EXECUTIVE SUMMARY

Introduction

Throughout North America, selected public agencies have been assigned the responsibility for monitoring commercial vehicle traffic to make sure the commercial vehicles operating on public roadways are in safe operating condition, have proper registration and operating authority, are within legal size and weight limits, and have paid all appropriate fees and taxes. To accomplish this goal, all 50 States have established roadside monitoring and enforcement programs.

With limited resources and increasingly heavy truck volumes, roadside enforcement activities must continually make decisions about which trucks to check and which to allow to proceed. This process of selecting some trucks for closer scrutiny, while allowing others to proceed unimpeded, is called “screening.” The effectiveness of enforcement is maximized (to the benefit of all stakeholders) if the program can target “high-risk” carriers and vehicles. Such targeting requires the ability to identify the commercial vehicle power unit and/or the motor carrier (or company) to determine if it is a good candidate for in-depth checks. By identifying the company and/or power unit, enforcement personnel are able to check the registration and tax status, as well as the safety-related history.

Roadside enforcement programs have traditionally identified commercial vehicles through the display of license plates, the posting of identifying numbers on the side of the truck cab, and miscellaneous paperwork that must be carried in the cab. Unfortunately, these identifiers must be read manually, and some, such as the paperwork in the truck cab, require the truck to be stopped in order for the information to be read. Thus, the screening process is slow and labor-intensive, resulting in delays for the motor carriers and high costs for the public agencies. This inefficient process also diminishes the effectiveness of enforcement, since it is not feasible to check identifying information on every truck.

In recent years, technologies have developed which offer the potential for automated roadside identification of commercial vehicles. Two of these technologies, radio frequency identification (RFID) and optical character recognition (OCR), have already been deployed for commercial vehicle screening purposes.

The Roadside Identification Feasibility Study was undertaken to identify methods of unique identification of commercial vehicles at the roadside for slow and high-speed electronic screening purposes. It was designed to be a comprehensive look at the technologies, focused on the needs of the Federal Highway Administration’s Office of Motor Carrier and Highway Safety (FHWA/OMCHS) and the States.

Methodology

This study was divided into four major tasks. Task A involved the identification of potential technologies (through a broad literature search and Request for Information (RFI)) and a needs assessment (through a survey of State agency representatives). This task led to the development of the Technology Matrix which was used and developed as the study proceeded. Task B involved a more defined search of the identified technologies. Task C was a synthesis and interpretation of the information, and Task D was the development of recommendations and preparation of the final report.

Findings

The Needs Assessment:

The survey of State agency representatives gathered information on both fixed-site (weigh stations) and mobile enforcement activities (temporary roadside enforcement locations and/or roving patrols). More than 85 percent of the States surveyed use both fixed sites and mobile teams for their commercial vehicle enforcement. The results from the survey were similar for both fixed and mobile enforcement.

Most States are able to check weight on every truck that comes through their enforcement facilities. By contrast, a small percentage of vehicles (the actual rate varies from state to state) get a credentials check and even fewer receive a safety inspection. Nearly all States indicated that they saw value in a system that could automatically identify a vehicle as it approached an enforcement location and verify specific information on the motor carrier and/or the power unit. The respondents listed the United States Department of Transportation (USDOT) number (to identify the motor carrier) and the license plate number (to identify the power unit) as the “best” identifiers to use.

Issues raised by the survey respondents included funding sources (for deployment), motor carrier acceptance, compatibility/interoperability among systems, and consistent identifiers for all trucks across North America. Respondents also commented on problems with currently available identifiers. It was noted that both the motor carrier and the power unit must be identified in order to perform a thorough check on the vehicle. Currently, this requires two different identifiers—one for the company and another for the power unit.

Common Identifiers:

Currently, there are at least six different identifiers for a motor carrier. These include the USDOT number, the Interstate Commerce Commission (ICC) number, the carrier name, the Federal Employer Identification Number (FEIN), the Dun and Bradstreet (DUNS) number, and the International Registration Plan (IRP) account number. All but the carrier name are unique, i.e., a given value of the identifier uniquely identifies a particular carrier. All interstate carriers have a USDOT number. All interstate, for-hire carriers have an ICC number, although this number is intended to be phased out. Federal regulations require the USDOT number and ICC number to be displayed on both sides of the commercial vehicle power unit. Some States assign

other identifiers to motor carriers and have additional requirements for what information must be displayed on the power unit.

There are three common identifiers for a commercial vehicle power unit: the license plate number, the Vehicle Identification Number (VIN), and the unit number. The license plate number (when combined with State of issue) and the VIN are unique identifiers; the unit number is assigned by the carrier and is not unique.

Other identifiers, such as a transponder identification number or a barcode label, identify a specific device or a label. The transponder or barcode label can be attached to a specific power unit or carrier in a roadside database.

National Information Systems:

Of course, identifiers are only valuable if they can be used to obtain pertinent information about the vehicle in question. Several national information systems are in existence or in development to provide access to this type of information. These include the Safety and Fitness Electronic Records (SAFER) system, the Motor Carrier Management Information System (MCMIS), SAFETYNET, the IRP and International Fuel Tax Agreement (IFTA) clearinghouses, and several others.

Technologies:

A list of 22 technologies that appeared to have some applicability to the task of roadside identification of commercial vehicles was initially generated. Nine of those technologies were found to be redundant (i.e., they simply used an alternative name, described a subset, or described a specialized version of another listed technology.) Another five technologies were eliminated from the list because they were judged to have little or no value for commercial vehicle identification.

The eight remaining technologies were carried forward and given a more thorough analysis. As the technology evaluation progressed, five of these technologies (OCR, RFID, barcode, image capture, and voice recognition) emerged as demonstrating the greatest potential for roadside identification of commercial vehicles. The remaining three technologies (global positioning systems (GPS), infrared (IR), and contact memory) were given a more cursory analysis.

Optical character recognition refers to the automatic interpretation of characters (letters and numbers) by capturing a video image and processing that image with special software. This technology has been available for about ten years and has been deployed for toll collection, traffic law enforcement, access control, commercial vehicle screening, international border crossings, travel time and origin/destination studies, and parking management. Several States have implemented and tested OCR systems for commercial vehicle identification and screening. These tests have used the license plate as the identifier. Testing to date has generated significant concerns regarding system performance levels, the effects of weather and environment, and the need for frequent maintenance and adjustment. One major hindrance to system performance has

been the inconsistency of the format, color scheme, and location of license plates on commercial vehicles, in addition to the poor (i.e., illegible) condition of many plates.

Radio frequency identification systems consist of a vehicle-mounted transponder and a roadside-mounted reader, which communicate with each other using radio frequency transmissions. These systems can be classified into three types, depending primarily on the frequency at which they operate. Inductive systems operate at low frequencies (100-500 kHz), have the shortest communications range (two to six meters), and have lower data transfer rates and reliability than the other types. Thus, they are limited to slow-speed applications. Electric Coupling systems operate at a higher frequency (900 Mhz), and have been widely deployed for electronic toll collection (ETC) and commercial vehicle electronic screening. Several million of these transponders are currently deployed on passenger cars and trucks, primarily for ETC. Accuracy and reliability have been high. Interoperability among systems is a major issue, as several vendors are currently competing for market share with proprietary protocols. A third type of RFID technology, Electronic Doppler Shifting, has been deployed for military applications, but is not yet commercially available. This technology is denoted by its high data transfer rates and extremely small transponder size.

Barcode systems consist of a barcode label mounted on the vehicle and a roadside-mounted scanner. The label consists of a pattern of light and dark elements that represent letters and numbers. The scanner uses a visible or IR laser to read the label. This technology has been used for toll collection, access control, and railcar identification. It is commercially available, and accuracy rates are high (unless the label becomes obscured, such as by dirt, grime, or snow). It is limited to slow-speed applications, and the scanner must be within a few feet of the vehicle.

Image capture systems capture a video image of a vehicle (showing appropriate identifiers) and display that image for a human observer to interpret. Thus, this technology is similar to OCR, except that it relies on a human (rather than computer software) to interpret the image. It has been deployed for traffic law enforcement and other uses, but not specifically for commercial vehicle identification.

Voice recognition is another useful tool for commercial vehicle screening. As with image capture, this technology does not provide automated identification. Instead, it allows an enforcement officer to read an identifier off the vehicle, speak the characters of the identifier into a microphone, and have that speech automatically interpreted by the computer. This avoids the need for entering the identifier via a keyboard or other mechanism, so it is particularly useful for situations where hands-free operation is desired (such as mobile enforcement).

Global positioning systems use satellite signals to continually calculate a vehicle's position. When coupled with onboard communications technologies, such as cellular, satellite, or radio, GPS allows the vehicle to broadcast its own position. Theoretically, this technology could be used for commercial vehicles to identify themselves to enforcement facilities. However, existing GPS systems are deployed by the trucking companies for fleet management functions, and there is little likelihood of these systems being used for enforcement purposes. Such use would require a high degree of trust and cooperation between the trucking companies and enforcement agencies.

Infrared and contact memory technologies could potentially be used for commercial vehicle identification, but neither seems well suited for roadside screening applications.

Motor Carrier Acceptance:

A key factor in implementing technologies for roadside identification of commercial vehicles is motor carrier acceptance. One of the guiding principles of the national Intelligent Transportation Systems Commercial Vehicle Operations (ITS/CVO) program is that motor carrier participation in ITS projects should be voluntary. However, the true meaning and implications of this principle are not well understood. For example, any roadside identification system that is implemented to identify all trucks is, by definition, non-voluntary. This is true regardless of the technology chosen, but there does appear to be a substantial difference in the current acceptance level for some technologies versus others. Specifically, there is strong resistance among motor carriers to the idea of a mandatory electronic identifier (such as a transponder), while there is less resistance to traditional, manual identifiers (even if they can be read automatically). The reasons for these differences, as well as the reasons for the resistance itself, are not well understood, but they may have profound impacts on the future of commercial vehicle enforcement in the United States.

Conclusions

States are in need of a quicker, more efficient way to screen commercial vehicles at both fixed and mobile enforcement locations. Most states are already weighing every vehicle, but the small number of vehicles currently being checked for safety and credentials problems makes it critical that high-risk carriers and vehicles be targeted. There is a need for a single, uniform identifier for the company and a similar identifier for the power unit. Identification will be simplified if these identifiers are displayed in a single location on the power unit.

Although there are several technologies capable of roadside identification, there are currently two preeminent technologies for automatic identification of commercial vehicles: RFID (Electric Coupling type) and OCR. These two technologies will compete for market share, and if either becomes universally used and accepted, the other becomes extraneous. Key factors that should influence the choice between these two technologies include cost, performance, and user acceptance.

For comparison purposes, the cost of deploying RFID technology to all 800 fixed weigh stations in the U.S., an additional 800 mobile/temporary sites, and three million trucks would be approximately \$110 million. The cost of deploying an equal number of OCR systems (assuming no expense for on-vehicle changes) would be approximately \$100 million. Both technologies can perform at both slow and high-speeds. However, the overall performance of OCR systems to date (35 to 45 percent accuracy for commercial vehicle applications) cannot compare to the accuracy of RFID (greater than 99 percent). Thus, from a strictly technical standpoint, RFID appears to be the clear choice. However, the issue of motor carrier acceptance must be considered. This issue needs to be well understood by those attempting to shape policy. It is of such paramount importance that it should be fully explored in an open and non-emotional forum.

Recommendations

Radio frequency identification should continue to be promoted and supported, including efforts to standardize technology and achieve interoperability across jurisdictional and functional lines. Testing of OCR technology should be conducted to determine the laboratory and real-world performance capabilities of the technology when applied to reading commercial vehicle license plates and identification numbers displayed on power units. Testing of voice recognition technology should continue. An assessment should be conducted of the feasibility of replacing current manual identifiers with electronic identifiers or incorporating an electronic identifier into a current identifier (such as the license plate).

Agreement should be reached on a single, unique identifier for each motor carrier and a single, unique identifier for each commercial vehicle in North America. Federal requirements for displaying identifiers on power units should be revised to use only the standard identifiers and to optimize readability by OCR systems. Consensus should be sought among States to conform to the Federal requirements and to develop a standard, North American, commercial vehicle license plate. This plate should also be designed for optimum readability by OCR systems.

A stakeholder forum should be established to explore and document the specific concerns of the motor carrier community and to provide guidance for the FHWA and State agencies in implementing electronic technologies. This forum will sort through the advantages, disadvantages, fears, and concerns, and will create a recommended path for implementation of commercial vehicle identification technologies to provide maximum benefit for all stakeholders.

1.0 INTRODUCTION

1.1 BACKGROUND

1.1.1 The Importance of Roadside Identification of Commercial Vehicles

Throughout North America, selected public agencies have been assigned the responsibility for monitoring commercial vehicle traffic to make sure that the vehicles traveling on public roadways are in safe operating condition, are within legal size and weight limits, are properly registered to operate, and have paid all appropriate fees and taxes. In order to monitor these parameters, all 50 States have established roadside monitoring and enforcement programs. These programs play a vital role in protecting the transportation infrastructure, maintaining the financial support for the transportation system, ensuring a level playing field for commercial vehicle operators, and protecting public safety.

Roadside enforcement activities can take place at a wide variety of locations. Much of this activity takes place at fixed facilities designed specifically for that purpose. These facilities, usually referred to as “weigh stations,” “ports of entry,” “inspection stations,” or simply “scales,” are typically located on major routes with substantial truck volumes. In addition, some enforcement activity takes place at temporary locations, where enforcement personnel set up, monitor traffic for a selected time period, and then move to another location. Other enforcement is truly mobile, where enforcement personnel patrol roadways looking for potential violators. The relative emphasis placed on mobile versus fixed enforcement activities varies substantially from State to State.

Wherever enforcement activity is conducted, it always requires enforcement personnel to answer questions about specific vehicles. At the most basic level, these questions deal with whether or not the truck is safe, legally registered, and of proper size and weight. However, since it is generally not possible to check every truck for all possible violations, the questions often focus on determining which trucks are likely to have violations and hence are good candidates for more thorough checks. This process of selecting certain trucks for additional attention, while allowing other trucks to proceed unimpeded, is usually called “screening.”

When screening trucks, many of the questions that must be answered by roadside enforcement personnel require the ability to identify the commercial vehicle power unit and/or the motor carrier. For example, in order to know if a given vehicle has valid registration, enforcement personnel need some form of identification for that power unit, such as a license plate number or Vehicle Identification Number (VIN). In order to verify that fuel taxes have been paid, they need to identify the company that is responsible for paying taxes for that vehicle. In order to determine if the vehicle has been placed out-of service for a safety violation or is a good candidate for a safety inspection, they need to access the safety record for the power unit and/or company. Even to do a thorough weight check, they need to know the registered legal weight for that power unit. All of these checks depend on the availability of some type of identifying information.

1.1.2 Traditional Methods of Roadside Identification

Public agencies have long sought to provide reliable and efficient mechanisms for identifying commercial vehicles at the roadside. Over the years, many requirements have been placed on truckers in an effort to achieve this goal. Some of these requirements dealt with information (i.e., cards, forms, and other paperwork) that needed to be carried in the truck cab. These requirements assisted enforcement personnel in obtaining the necessary identification information for a truck that was stopped for some level of inspection. Other requirements have been added for the external display of information. Examples of this would include license plates, various numbers displayed on the truck, decals, and placards.

External displays simplify the process of obtaining identification information on a truck, thus speeding up the screening process. With external identifiers, it is possible to identify the truck and/or the company without the necessity of stopping the truck or having the driver dismount. However, these displays still rely on a human observer to read the identifying information and use it as input to verify information on the vehicle..

1.1.3 Recent Developments

Over the last ten years or so, significant attention has been focused on developing automated methods of identifying a commercial vehicle at the roadside. The use of electronic technologies to identify and screen trucks at enforcement locations is referred to as “electronic screening.” Several different technologies have been developed which can be used for this purpose, and some have been deployed and tested. The most prominent technology has been Radio Frequency Identification (RFID), also known as dedicated short-range communications (DSRC) or automatic vehicle identification (AVI). This approach uses truck-mounted transponders and roadside readers, which communicate with each other via radio frequency transmissions. The transponder usually contains a unique identification number, which can be associated with a particular truck and/or company in a roadside database. The transponder may also have additional memory which can be used to store application-specific data.

Deployment of RFID systems has been rather widespread. The major applications have been electronic toll collection (ETC), commercial vehicle electronic screening at weigh stations, and international border crossings. Several million transponders have been deployed (on passenger cars and trucks) for ETC, while 50,000 to 100,000 trucks have been equipped with transponders specifically for electronic screening. Nearly 100 weigh stations in the United States and Canada have been equipped to perform electronic screening of transponder-equipped trucks.

RFID technology has proven to be an effective and reliable method for identifying those vehicles that are equipped with an appropriate transponder. The obvious limitation of the technology is that only a small percentage of trucks currently have these devices. There are also substantial issues related to compatibility and standards, as several vendors compete for market share with proprietary systems. These issues are currently being addressed by the United States Department of Transportation (USDOT), various stakeholder groups, and the trucking industry.

Another prominent technology that has surfaced is Optical Character Recognition (OCR). This technology uses video cameras to capture an image of the vehicle, an image which includes some alphanumeric identifier (such as the license plate). Special software is used to interpret the image and recognize characters (i.e., numbers, letters, or shapes). License plate reader (LPR) systems have been deployed for toll collection (for compliance verification); for automated enforcement of speed limits, red lights, and high-occupancy vehicle lanes (to identify violators); for international border crossings; and for commercial vehicle fleet management (for identification/documentation at a terminal). They have also been tested (on a limited scale) for commercial vehicle identification, to identify high-risk carriers or out-of-service violators.

RFID and OCR are just two of the technologies in existence or under development that could be applied to the problem of roadside identification of commercial vehicles. The potential value of such technologies in improving the efficiency and effectiveness of commercial vehicle enforcement activities is enormous. The benefits of such improvements would extend not only to State agencies, but also to safe and legal motor carriers and the general public.

1.2 OBJECTIVES

The stated objective of this feasibility study was to identify methods of unique identification of interstate commercial vehicles at the roadside for slow and high-speed electronic screening purposes. It was designed to be a comprehensive look at available and developing technologies, focused on the needs of the Federal Highway Administration's Office of Motor Carrier and Highway Safety (FHWA/OMCHS) and the States.

2.0 METHODOLOGY

The Roadside Identification Feasibility Study was divided into four major tasks. The first task (Task A) was divided into two sub-tasks (A.1 and A.2). Task A.1 involved the identification of potential technologies through a broad literature search and Request for Information (RFI). In Task A.2, a needs assessment was conducted by surveying State agency representatives. This resulted in the development of the Technology Matrix which was used and further developed as the Study proceeded. Task B involved a more defined search of the identified technologies. Task C was a synthesis and interpretation of the information, and Task D was the development of recommendations and preparation of the final report..

The following paragraphs present additional detail on how each Task was conducted.

2.1 TASK A.1: BROAD LITERATURE SEARCH AND REQUEST FOR INFORMATION (RFI)

The Internet, electronic discussion lists and news groups, bibliographic databases, and various technical publications were accessed in a broad search for vehicle identification technologies. The purpose of this search was to simply identify technologies that might be used for commercial vehicle identification. These technologies were then investigated thoroughly in Task B, the defined literature search.

In conjunction with the broad search, an RFI was released to identify technologies still under development. The RFI was advertised in various Intelligent Transportation Systems (ITS) and business publications and was sent directly to more than 100 ITS vendors. It generated more than 20 responses. A copy of the RFI can be found in Appendix A.

2.2 TASK A.2: NEEDS ASSESSMENT AND MATRIX DEVELOPMENT

In order to assess which technologies could best meet the needs of the OMCHS and the States, it was first necessary to understand those needs. To assist in this process, several contacts within the OMCHS reviewed the work throughout the duration of the project. For the States, a list of questions was developed for use in conducting a survey. A copy of the survey form and results can be found in Appendix B. A point of contact was identified in each of the 50 States. All surveys were conducted by phone, with the exception of three State representatives who asked to complete the survey in writing. In total, 46 States participated in the survey. Appendix C provides information on the points-of-contact for the participating States. The survey results were tabulated for presentation and to assist in preparing the Technology Matrix.

This study involved the collection of large amounts of information related to numerous technologies. In order to provide some uniformity in the type of information collected and how that information would be presented, it was necessary to develop a framework for collecting and displaying information. That framework is the Technology Matrix. The original matrix, developed in Task A.2, consisted of a single table, with specific technologies listed down the left-

hand column and attributes listed across the top. The broad literature search and RFI responses provided the initial list of technologies. The attributes were determined based on the literature search, the RFI responses, and the needs assessment.

The Technology Matrix was revised several times as the project progressed. As additional information was collected, the matrix was revised to provide additional clarity, add new attributes, or remove attributes that proved to be of little or no value.

2.3 TASK B: DEFINED LITERATURE SEARCH

The defined literature search was targeted to obtain the necessary information to fill in the Technology Matrix. Various key words associated with the identified technologies were researched. The Internet, bibliographic databases, electronic discussion lists and news groups, and ITS publications were used once again to investigate national and international experiences with the various types of technologies. Respondents to the RFI were also interviewed as part of this Task.

2.4 TASK C: SYNTHESIS OF LITERATURE SEARCH

In theory, this task involved assembling the results of the defined literature search, separating the pertinent information from the extraneous, putting the information into presentable form, and filling in the blanks of the Technology Matrix. In practice, it required several iterations of many steps and some detours along the way. Since the available literature on various technologies varied substantially in the type of information provided, numerous phone contacts had to be made in order to achieve some uniformity in the information presented. A concerted effort was made to contact both suppliers and users of each technology. Wherever possible, information provided by suppliers was corroborated by users. As information became available and the matrix was being filled, it became clear that some fields in the matrix were of little value and could be eliminated. Other information was useful, but did not fit in the original matrix format, so the format was revised several times. The matrix actually evolved into two matrices, one describing the available identifiers for commercial vehicles and the other describing the available technologies.

The project team recognized that the final product might easily reflect their own perceptions, biases, and gaps in knowledge. To minimize that possibility, an “expert review panel” was assembled to review the matrices for accuracy and completeness. A list of the panel members can be found in Appendix E. As the matrices and the report neared completion, members of the review panel were asked to review the materials and provide comments on errors or omissions. Despite significant time constraints, the review panel was able to provide extremely valuable input, which greatly enhanced the quality of the final product.

2.5 TASK D: RECOMMENDATIONS AND FINAL REPORT

Using the matrices, the survey results from Task A.2, the authors’ experience with commercial vehicle electronic screening systems, and the input from the expert review panel, a set of recommendations was developed and incorporated into a final report. A draft version of this

report was circulated for review by the selected FHWA staff and the expert review panel. Comments from that review were used to revise the report into its final form.

3.0 FINDINGS

3.1 THE NEEDS ASSESSMENT

Commercial vehicle enforcement personnel generally provide enforcement in three areas: safety, size and weight, and credentials. The relative emphasis given each of these areas varies from State to State, as does the division of responsibilities among the various State agencies.

The intent of safety enforcement is to identify any vehicles or drivers that have an unsafe condition and ensure that the unsafe condition is corrected. Safety enforcement is usually conducted by means of truck inspections. Different levels of inspections can be performed, depending on how thorough of a check an inspector determines is necessary. These can range from a quick visual “walk-around” inspection to a full Commercial Vehicle Safety Alliance (CVSA) Level 1 inspection, which may take 30-45 minutes to complete.

Size and weight enforcement is intended to make sure that all vehicles are within legal limits for length, width, height, gross weight, individual axle weights, and combination axle weights. Vehicles in violation of these limits can create safety hazards and/or cause accelerated damage to the roadway. Weight checking can be accomplished by means of static scales, which require the truck to stop on the scale, or weigh-in-motion (WIM) scales, which weigh the truck while it is moving. Since WIM scales are not considered accurate enough for enforcement (i.e., issuing weight citations), they are usually used for sorting purposes, with “questionable” trucks being directed to the static scales. Size enforcement is sometimes accomplished with automatic detectors (such as height detectors), or it may require manual measurement by enforcement personnel.

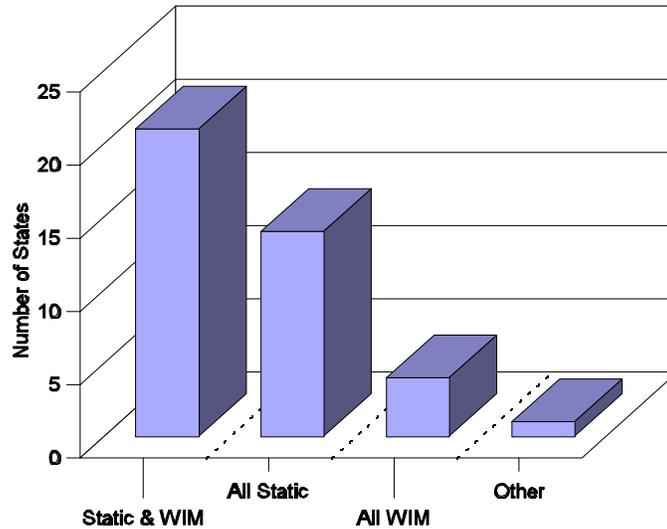
Credentials enforcement refers to the checking of items related to registration, taxes, operating authority, licensing, or other “paperwork” items. Traditionally, checking these items has required the driver to bring in various paperwork carried in the truck cab. In recent years, however, there has been increase usage of computer databases to verify credentials information.

These functions are typically carried out by enforcement personnel at fixed sites or by mobile enforcement units using temporary roadside locations or roving patrols. More than 85 percent of the States surveyed have both fixed sites and mobile teams for commercial vehicle enforcement.

3.1.1 Fixed Site Enforcement

Of the 42 States with fixed sites, many are looking for quicker, more efficient ways to screen commercial vehicles. Eighteen States have at least one site with mainline screening capabilities, and another four States have such sites planned or under construction. Sixteen States are using mainline WIM to weigh trucks at high speeds. Within the station, most States continue to use static scales, although many States are also using ramp WIM scales to sort vehicles. Figure 1 illustrates the types of scales used within fixed enforcement locations. Nearly 75 percent of the States weigh every vehicle that comes through these fixed stations. The remaining States weigh only a portion of the vehicles based on random selection or visual clues.

Figure 1: Scale Type Within Fixed Stations



Because of the high volume of traffic at these fixed stations, only one State (Hawaii) is able to perform a full safety inspection on all vehicles passing through the station. In fact, more than 80 percent of the States claim to fully inspect less than 5 percent of the vehicles passing through the station. Forty percent of the States estimate that less than 1 percent of the vehicles are inspected. For this reason, it is critical that “high risk” carriers are targeted for inspection.

When choosing a vehicle for inspection, nearly 70 percent of the States claim to use some identifying information off the truck. Typically, selection is either random, based on some visual observation of the officer, or based on the officer’s experience or inexperience with a particular carrier (See Figure 2). In addition, some States occasionally use the Inspection Selection System (ISS), which keys off the USDOT number, to choose vehicles for inspection. The State of Iowa has an automated system that uses LPR technology to identify and target carriers in the Performance and Registration Information Systems Management (PRISM) program.

From the standpoint of safety enforcement, 95 percent of the States see value in a system that could automatically identify the carrier and/or the power unit as it approached an inspection/weigh station. For such a system, the USDOT number was recommended most often as the best identifier to use, followed by the license plate (See Figure 3).

Although considered the “best” identifiers to obtain safety information, the USDOT number and license plate are not without flaw. One problem specifically noted about the USDOT number is that it identifies only the carrier and not the specific commercial vehicle power unit. Likewise, the license plate identifies the power unit, but may not identify the motor carrier currently responsible for the safety and/or taxes of that vehicle. One State suggested that the ideal identifier would be a combination of a carrier identifier (USDOT or Interstate Commerce Commission (ICC)) and a power unit identifier (license plate or VIN). It was also noted by several States that although an automated system would be very helpful, it could not replace an officer’s visual inspection of the vehicle or his/her experience with a specific carrier.

Figure 2: Methods of Selection for Inspection

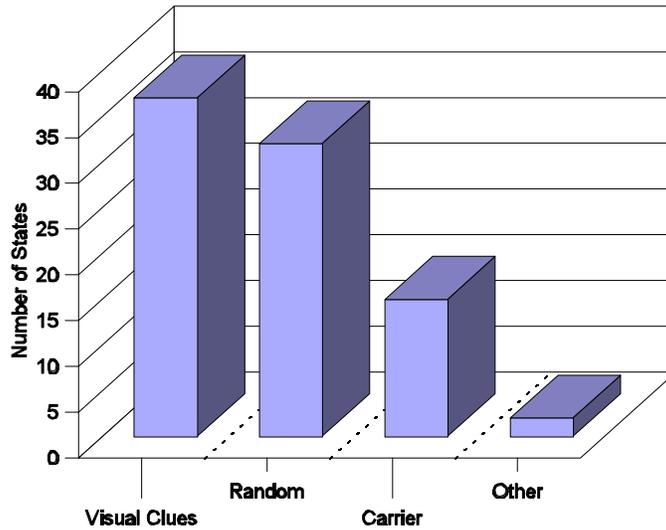
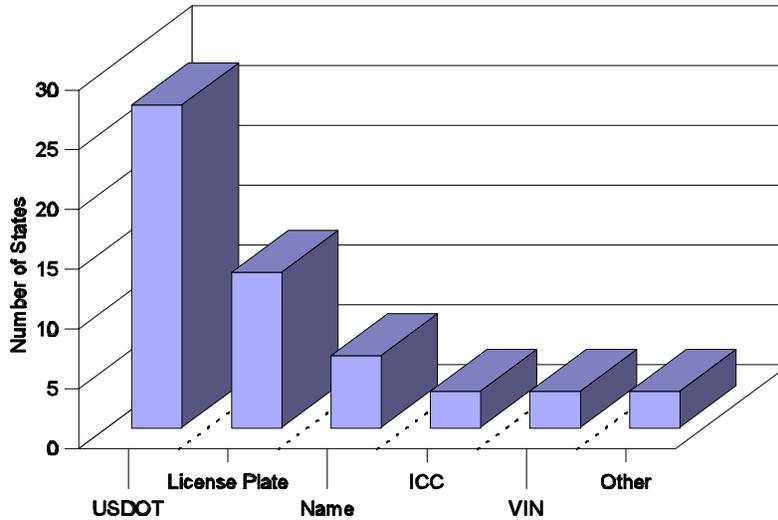


Figure 3: Recommended Identifiers for Safety Information



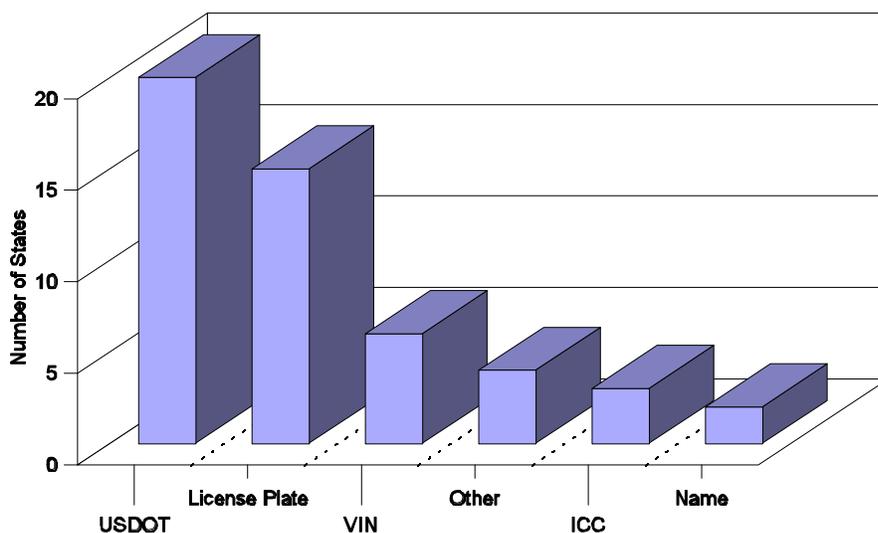
When selecting vehicles for a credentials check the process is similar to that of selecting vehicles for inspection. It is often done randomly, by visual check, or based on prior experience (or inexperience) with a specific carrier. Many States use the same method they would use to stop a vehicle for inspection. In fact, trucks that are stopped for inspection usually get a credentials check also.

Because credentials checking is less time-consuming than a full inspection, the number of vehicles in each State that get a credentials check is higher than the number inspected for safety. Five States (Arizona, Colorado, Hawaii, Oregon, and Wyoming) check the credentials of every vehicle that comes through their stations. Arizona, Hawaii, and Wyoming manually check some of the paperwork for every vehicle, while Colorado and Oregon have databases that allow them to key in identifying information off the vehicle and verify registration. Kentucky also has such a

database, but they only claim to verify registration information on 60 to 70 percent of the vehicles. Due to high traffic volumes and scarce resources, nine States reported that they are only able to verify credentials on 5 percent or less of the vehicles.

From the standpoint of credentials enforcement, nearly 98 percent of the States see some benefit in a system that could automatically identify a vehicle as it approached an inspection/weigh station. Again, most States feel the USDOT number or license plate is the best identifier to use (See Figure 4).

Figure 4: Recommended Identifiers for Credentials Information

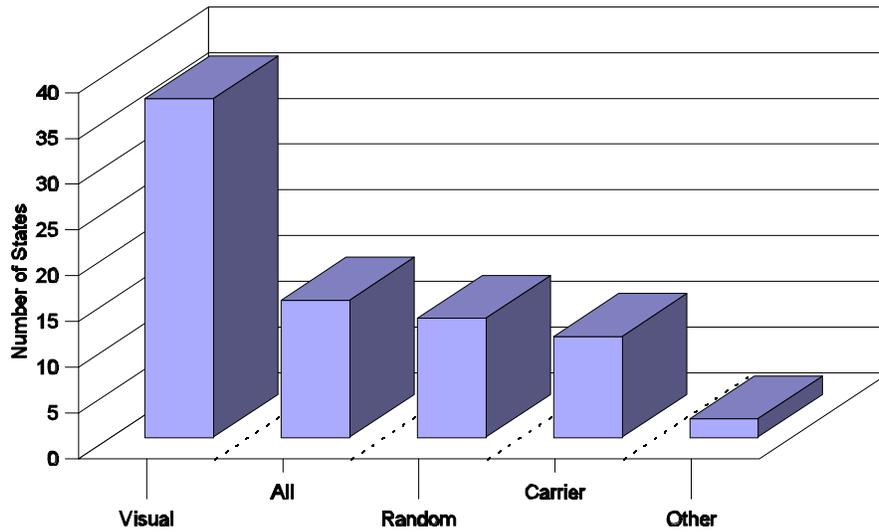


3.1.2 Mobile Enforcement

All of the States surveyed have mobile enforcement programs, making use of temporary roadside locations, roving patrols, or both. The majority (84 percent) use both temporary roadside locations and roving patrol units. In addition, Washington and North Carolina occasionally set up enforcement activities at other locations such as trucking facilities or their State Fair. The remaining 7 States (16 percent) use either temporary locations or roving patrols, but not both.

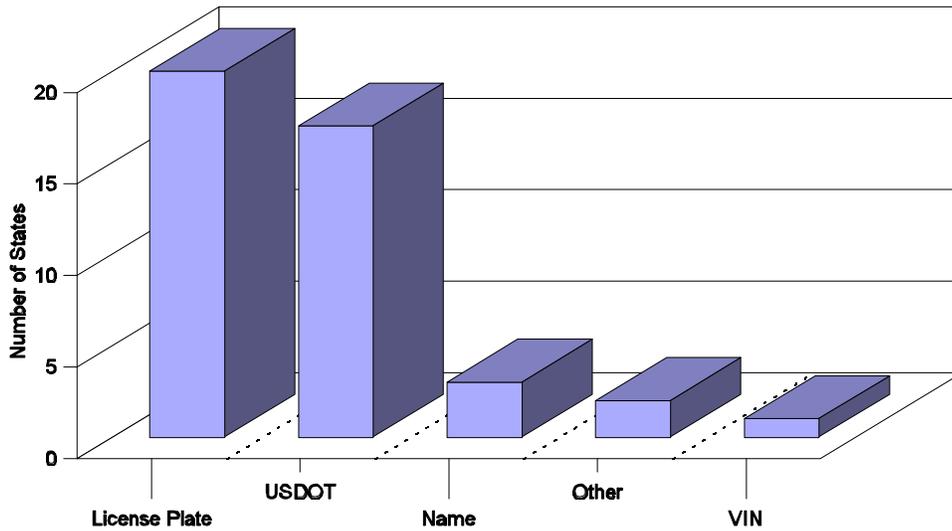
During mobile enforcement activities, vehicles are stopped for weight checking, safety inspection, and/or credentials verification based on either random selection, visual clues detected by an officer, or specific experience (or inexperience) with a particular carrier. Most often, the vehicle is stopped based on a visual inspection by an officer (See Figure 5). For instance, an officer may stop a vehicle that appears to be overweight or have safety problems. The officer may also visually check the license plate or CVSA sticker before stopping the vehicle. Although selection is random in some States, at least 11 States require probable cause prior to stopping a commercial vehicle. Depending on traffic conditions, many States will attempt to stop all commercial vehicles at the temporary roadside locations.

Figure 5: Selection for Stop by Mobile Enforcement



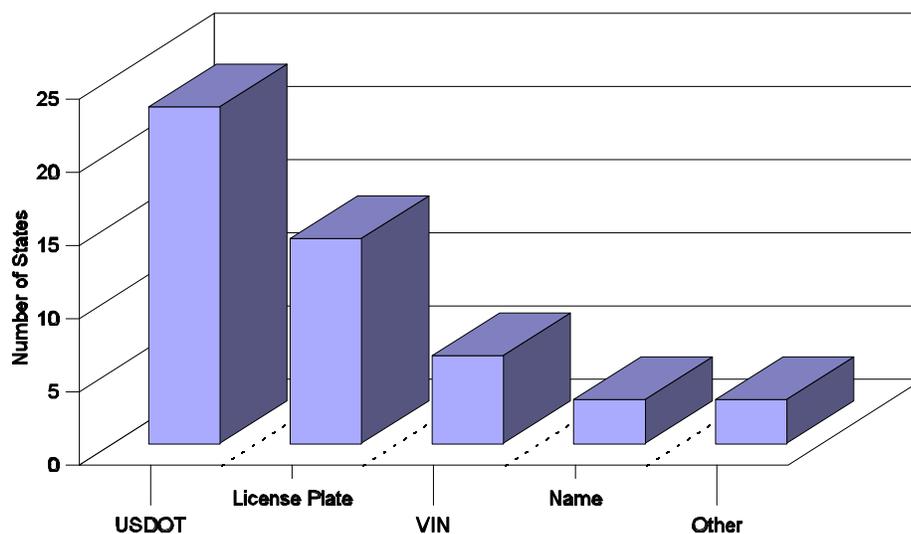
Nearly 85 percent of the States use identifying information off the vehicle to verify specific safety and/or credentials information on the vehicle or carrier. Typically the identifying information used is the license plate or the USDOT number (See Figure 6). With the license plate, States are able to verify certain information by calling a dispatcher. Most States have the capability of using the USDOT number with ISS, but few are actually doing so.

Figure 6: Identifiers Used to Verify Information by Mobile Enforcement



From the standpoint of mobile enforcement for both safety and credentials verification, 91 percent of the States see value in a system that could automatically identify a vehicle. This is slightly lower than for fixed stations, but still a very high percentage. Once again, the identifier of choice would be the USDOT number, with the license plate following closely behind (See Figure 7).

Figure 7: Recommended Identifiers for Use by Mobile Enforcement



3.1.3 Key Issues

With regard to actually implementing systems for automatic identification of commercial vehicles, common issues raised by the States for both mobile and fixed enforcement included funding sources (i.e., who would provide funding for such systems), motor carrier acceptance, and compatibility among systems. These issues were identified as being critical for national deployment. There was also interest expressed in an international system that would include all truck traffic in North America.

Many States commented on problems with current identifiers. Specifically, there is no single identifier that provides all the needed information. The USDOT and ICC numbers identify the company, but have no direct connection to the specific power unit or the driver. The license plate or VIN can be used to identify the power unit, but this does not identify the company for which the vehicle is operating. One State suggested that USDOT numbers should be issued to both interstate and intrastate carriers, while another State recommended pursuing a national license plate that was specific to a power unit.

3.2 COMMON IDENTIFIERS

There are a variety of identifying numbers or characters that may be used to identify a motor carrier or an individual power unit. A detailed description of some of these identifiers follows. Table 1 provides a quick comparison. In the discussion (and the Table), some identifiers are described as “unique,” meaning that a given value of the identifier will be assigned to only one carrier or power unit. If an identifier is not unique, then two or more carriers (or power units) might have the same value for the identifier.

Table 1: Identifier Matrix

Identifier	Required for:	What does it identify?	Is it Unique?	Format	Location on Vehicle	National Systems Containing Identifier
USDOT Number	All interstate and some intrastate carriers	Motor Carrier	Yes	USDOT #####	On both sides of the power unit	SAFER, MCMIS, SAFETYNET, IRP Clearinghouse, Licensing and Insurance Database
ICC Number ¹	All for-hire interstate carriers	Motor Carrier	Yes	ICC MC #####	On both sides of the power unit	SAFER, MCMIS, SAFETYNET, Licensing and Insurance Database
License Plate	All power units	Power Unit ²	Yes	≤ 9 alphanumeric combinations and state identification	Front of the power unit ³	IRP Clearinghouse, SAFER, NLETS, ITDS
VIN	All power units	Power Unit	Yes	17-character alphanumeric combination	Various	IRP Clearinghouse, SAFER, SAFETYNET, MCMIS Accident Data, NMVTIS, ITDS
Carrier Name	All motor carriers	Motor Carrier	No	up to 55 Characters	On both sides of the power unit	SAFER, MCMIS, SAFETYNET, Licensing and Insurance Database
Unit Number	No requirement	Power Unit	No	No standard, various	Various	SAFER, MCMIS Inspection Data
FEIN	All motor carriers	Motor Carrier	Yes	9 digit ##-##### or ###-##-####	Various, no federal requirement	SAFER, MCMIS, IFTA Clearinghouse, IRP Clearinghouse
DUNS	No requirement	Motor Carrier (site specific)	Yes	9 digit ##-###-####	Various	MCMIS, SAFER, ITDS, FARS
IRP Account Number	All interstate carriers	Motor Carrier	Yes	AA #####	Various, no federal requirement	IRP Clearinghouse, SAFER
Transponder Number	No requirement	Transponder ⁴	Yes	Various	windshield, bumper, roof or side of cab/trailer ⁵	SAFER ⁶
Barcode	No requirement	Barcode Label	Yes	8 digits ⁷	side of cab/trailer ⁵	N/A

¹ Over the next two to three years, the ICC Number will be phased out. The USDOT number will be used in its place.

² A separate license plate identifies the trailer.

³ State laws may vary on the specific location of the license plate.

⁴ Transponders may eventually be built into the cab of the truck, greatly increasing the population of transponder-equipped trucks.

⁵ Actual number does not appear.

⁶ Actual population of this field in SAFER may be difficult.

⁷ Vehicle identification barcode labels are typically eight digits. Other barcode labels may vary.

3.2.1 United States Department of Transportation (USDOT) Number

This unique number is issued by the FHWA/OMCHS to all interstate carriers. By authority of the OMCHS, some States are issuing USDOT numbers for intrastate carriers as well (1). The number is displayed on both sides of the power unit, preceded by the letters "USDOT" (for example, "USDOT 123456"). The Federal Motor Carrier Safety Regulations state that the letters and numbers must be in sharp contrast with the background, legible during daylight hours from 50 feet while the vehicle is stationary, and maintained to retain legibility (2). The USDOT number can be found as a field in such national information systems as the Motor Carrier Management Information System (MCMIS), the Safety and Fitness Electronic Records (SAFER) Carrier Snapshot, SAFETYNET, International Registration Plan (IRP) Clearinghouse and the Licensing and Insurance Database.

3.2.2 Interstate Commerce Commission (ICC) Number

This unique number was formerly issued by the ICC, and is now issued by the FHWA, to all for-hire interstate carriers. The Federal Motor Carrier Safety Regulations are currently being revised to eliminate the requirements for carriers to display the ICC number on the power unit. Until that time, the ICC number will continue to be issued by FHWA/OMCHS, and it will still be visible on some vehicles for at least 2 years after the new regulation has passed (3). The number is displayed on both sides of the power unit, preceded by the letters "ICC MC" (for example, "ICC MC 123456"). The letters must be in sharp contrast with the background, legible during daylight hours from 50 feet while the vehicle is stationary, and maintained to retain legibility (4). The ICC number can be found in such national information systems as SAFER Carrier Snapshot, MCMIS, SAFETYNET, and the Licensing and Insurance Database.

3.2.3 License Plate

The license plate uniquely identifies a commercial vehicle power unit and is issued by a State to all commercial vehicles based in that State. (A license plate is also issued to each trailer.) The license plate number, by itself, may not be unique, but it is unique when combined with the State where it was issued. The format of the license plate varies from State to State, but includes no more than 9 alphanumeric characters and State identification. For combination units (a power unit with a trailer), the plate is always displayed on the front of the tractor. For a single-unit truck, the location of the plate varies by State. National information systems that may be accessed with the license plate number include: IRP Clearinghouse, SAFER Vehicle Snapshot, International Trade Data System (ITDS), and National Law Enforcement Telecommunications System (NLETS).

3.2.4 Vehicle Identification Number (VIN)

This unique, 17-character, alphanumeric combination is issued to the power unit by the vehicle manufacturer (5). The VIN is placed on the door jamb and the left side of the frame behind the steering box (6). There is no federal requirement that the VIN be displayed on the outside of a commercial vehicle. National information systems that contain the VIN include: IRP

Clearinghouse, SAFER Vehicle Snapshot, MCMIS Accident Data, ITDS, SAFETYNET Accident Data, and National Motor Vehicle Title Information System (NMVTIS).

3.2.5 Carrier Name

This non-unique identifier is chosen by the carrier and has no specific length limit (although, the MCMIS database has a 55 character limit for the carrier name field) (1). For all interstate carriers, the carrier name must be displayed on both sides of the power unit. The letters must be in sharp contrast with the background, legible during daylight hours from 50 feet while the vehicle is stationary, and maintained to retain legibility (2). National information systems that contain the carrier name include: SAFER Carrier Snapshot, MCMIS, SAFETYNET, the Licensing and Insurance Database, IRP Clearinghouse, International Fuel Tax Agreement (IFTA) Clearinghouse, and ITDS.

3.2.6 Unit Number

This non-unique identifier is issued to a power unit by the carrier. There is no standard for the format or placement of unit numbers on a vehicle, although some States require it. National information systems that contain the unit number include: SAFER Vehicle Snapshot and MCMIS Inspection Data.

3.2.7 Federal Employer Identification Number (FEIN)

This unique nine-digit identifier is issued by the Internal Revenue Service to all carriers (7). The format for the number may be “12-3456789” or “123-45-6789”. There is no federal requirement to display the FEIN on the vehicle, nor is there likely to be, since the number could be a social security number. National information systems that contain the FEIN include: SAFER Carrier Snapshot, MCMIS, IFTA Clearinghouse, and IRP Clearinghouse.

3.2.8 Dun and Bradstreet (DUNS) Number

This nine-digit number is issued by Dun & Bradstreet and uniquely identifies a motor carrier. The format for the DUNS number is “12-345-6789” (8). There is no federal requirement to have or display the DUNS number. National information systems that contain the DUNS number include: MCMIS, SAFER Carrier Snapshot, ITDS, and Fatal Accident Reporting System (FARS).

3.2.9 International Registration Plan (IRP) Account Number

This unique eight-character alphanumeric identifier is issued by a State on the authority of the IRP. The number identifies the motor carrier and is required for all interstate vehicles. The format for the IRP Account Number is “AA 123456”, where “AA” is the two letter State abbreviation of the vehicle’s base State (9). There are no federal requirements to display the IRP Account Number on the vehicle. National information systems that contain the IRP Account number include: the IRP Clearinghouse and SAFER Carrier Snapshot.

3.2.10 Transponder Number

This unique number is issued by the transponder manufacturer to a transponder. The transponder number is then linked to a specific power unit and/or motor carrier in a database. There are currently no Federal or State requirements to have a transponder. In most cases, the transponder is located on the windshield, but it may be on the bumper, roof, or side of the power unit (10). There is some discussion of possibly including a transponder in future power units when manufactured, which could greatly increase the transponder population (11). The SAFER vehicle snapshot has a field for transponder number, but this field may prove difficult to populate. Transponder identification numbers are considered proprietary or private information by some electronic screening and toll collection programs.

3.2.11 Barcode number

This unique number is issued by the barcode manufacturer to a vehicle barcode label. The barcode label is then attached to the side of a power unit and is linked to the power unit and/or motor carrier in a database. Typical format for a barcode label is eight digits, but the format may vary (12). It is also possible to barcode vehicle, owner and other information. Some States, like Iowa and Colorado, have barcoded carrier information on the vehicle registration documents (1). There are currently no Federal or State requirements to have a barcode label on the vehicle, and there are no national information systems that include a barcode number.

3.3 NATIONAL INFORMATION SYSTEMS

The various identifiers are only as valuable as the information they can provide. Following is a brief description of the national information systems that include these common identifiers.

3.3.1 Safety and Fitness Electronic Records (SAFER)

This system is currently under development by The Johns Hopkins University Applied Physics Laboratory (JHU/APL) and is operated by Science Applications International Corporation (SAIC) for the FHWA/OMCHS. SAFER currently provides limited functionality and uses carrier information from existing motor carrier safety databases. In the future, SAFER will contain carrier, vehicle, and (potentially) driver “snapshot” data, which will be a convenient source to obtain a quick overview of a particular carrier, vehicle, or driver. The primary key for accessing the carrier snapshot will be the carrier identification number (USDOT number for interstate and some intrastate carriers), but it will also contain other carrier-level identifiers, such as the DUNS number, the ICC number, and the carrier name. The primary key for the vehicle snapshot will be the VIN, but other identifiers, such as the license plate number, unit number, and transponder number, will be included as well (13).

3.3.2 Motor Carrier Management Information System (MCMIS)

This system is the authoritative source for safety information on interstate and some intrastate carriers and hazardous material shippers who are subject to the Federal Motor Carrier Safety Regulations or Hazardous Materials Regulations. MCMIS contains census information,

performance reviews and ratings, inspection data, crash reports, and enforcement records. It is maintained by the FHWA/OMCHS and accessible through SAFETYNET by more than 70 FHWA field offices and 51 Motor Carrier Safety Assistance Program (MCSAP) State offices, as well as certain Canadian Provinces. Most data items in MCMIS are also made available to industry and public requesters (1).

3.3.3 SAFETYNET

SAFETYNET is a cooperative effort to share motor carrier information among States and the FHWA. The SAFETYNET software is an automated information management system designed to assist motor carrier safety offices by allowing State agencies to provide motor carrier safety data to FHWA. SAFETYNET consists of the following 7 subsystems: inspection, accident, carrier search, Safety Reviews/Compliance Reviews, Micro Census, Reports Generation, and Communications (1).

3.3.4 Licensing and Insurance System

The Licensing and Insurance system is operated and managed by the John A. Volpe National Transportation Systems Center for the USDOT. The purpose of the system is to ensure suitable insurance coverage and compliance with Federal Motor Carrier Safety Regulations and to inform the public of all licensing transactions for interstate carriers.

3.3.5 International Registration Plan (IRP) Clearinghouse

This system facilitates the storage and transfer of registration data for all the States. Each State transmits vehicle registration information and fees to the clearinghouse, which distributes the information and fees to other States. Currently ten State agencies are using this clearinghouse (14).

3.3.6 National Law Enforcement Telecommunications System (NLETS)

This national system provides State and local law enforcement with the ability to exchange criminal-justice-related information. Government agencies with law enforcement functions have access to this system (15).

3.3.7 International Fuel Tax Agreement (IFTA) Clearinghouse

This system allows States to access a single database to process fuel tax returns, calculate net amounts due to and from a base jurisdiction, resolve discrepancies, electronically track fuel taxes between a base jurisdiction and a reporting jurisdiction, maintain related information, and electronically distribute fuel tax data. Only State agencies have access to this clearinghouse (16).

3.3.8 National Motor Vehicle Title Information System (NMVTIS)

This system was developed by the Department of Justice and the Department of Transportation to obtain title and registration information on any vehicle. According to the Anti

Car Theft Act of 1992, this information is made available to Federal, State and local law enforcement officials, insurance carriers, and prospective purchasers of vehicles (17).

3.3.9 International Trade Data System (ITDS)

This system is being developed by various branches of the United States Government to improve trade procedures, trade promotion, trade policy development, and trade statistics to benefit both the public and the government (18).

3.3.10 Fatal Accident Reporting System (FARS)

This is a collection of files maintained by the National Highway Traffic Safety Administration (NHTSA) documenting all fatal crashes since 1975 that occurred within the 50 States, the District of Columbia, and Puerto Rico. This information is available to the general public (19).

3.4 TECHNOLOGY REVIEW

The broad literature search and the RFI generated a preliminary list of 22 technologies that appeared to have some applicability to the task of roadside identification of commercial vehicles. A preliminary investigation revealed that nine of the listed technologies were redundant (i.e., they simply used an alternative name, described a subset, or described a specialized version of another listed technology). The remaining 13 technologies are listed here.

- Optical character recognition (OCR)
- Radio Frequency Identification (RFID)
- Barcode
- Image Capture
- Voice Recognition
- Infrared (IR)
- Contact Memory
- Global Positioning Systems (GPS)
- Magnetic Data Capture (Magnetic Strip Cards)
- Chip and Laser Cards (Smart Cards)
- Acoustical Signature Analysis
- Optical Cards
- Biometrics

As the preliminary investigation continued, five of these technologies were judged to have little or no value for commercial vehicle identification. Specifically, it was determined that acoustical signature analysis was suitable for identifying the type of vehicle, but not a specific vehicle. Similarly, biometrics technology is used to identify a person, not a vehicle. Three of the technologies involved using some type of card (optical, magnetic strip, and smart cards). While these technologies could be used for roadside identification purposes, they each require direct contact (or extremely close proximity) between the card and the reader. Thus, they did not

appear to offer any significant efficiency gains over traditional methods of roadside vehicle identification.

The eight remaining technologies were carried forward and given a more thorough analysis. As the technology evaluation progressed, five of these technologies (OCR, RFID, barcode, image capture, and voice recognition) emerged as demonstrating the greatest potential for roadside identification of commercial vehicles. These five technologies were evaluated in some detail, while the remaining three (GPS, IR, and Contact Memory) were given a more cursory analysis. A detailed description of each of the technologies follows. In addition, specific information for each of the five primary technologies has been summarized on informational sheets and can be found in Appendix E. Certain performance characteristics and equipment information has been summarized for easy comparison in Table 2.

3.4.1 Optical Character Recognition (OCR)

Optical character recognition is the automatic interpretation of human-readable characters (20). With OCR, any legible identifier on a vehicle has the potential of being “read” optically. With regard to vehicle identification, OCR has been used almost exclusively with the license plate. Related work for freight identification has been done with maritime container codes.

A typical single-lane OCR installation will include: an illuminator, a trigger, cameras (one or more depending on the application), a central processing unit, a character recognition engine, and a storage or transmission system. Installation for more than one lane will require additional lighting, triggers, cameras, and possibly central processing units. There is no special equipment required on the vehicle. The equipment is best suited for fixed applications (21). Although mobile systems have been produced, experience has shown that highly trained individuals are required for proper setup of the equipment (22).

Additional lighting is necessary at the roadside to obtain “OCR readable” images at all times of the day and in all weather conditions. The light source may be visible or IR, incandescent or strobe. It must be bright enough to obtain legible images in all conditions, but not distracting or blinding to the driver. The camera typically captures images from about 20 feet, but may be used as far as 75 to 100 feet away. The cameras are capable of capturing and identifying vehicles going up to 90 mph (21).

The equipment is made to withstand extreme temperatures and weather conditions, but there are reports that the equipment is not durable or rugged enough for the roadside. Vendor-reported maintenance for OCR systems includes cleaning of the cameras, lights, triggers, and hard drive space monthly, but some States who have deployed the technology report extensive maintenance, including frequent cleaning and adjustments to the camera (21, 23).

Table 2: Technology Matrix

Automation	Technology	Technology Comparison													
		Additional Equipment Required on Vehicle	Is the system portable?	Are there existing standards?	Applicable Safety Regulations	Maximum Distance from Vehicle	Maximum Speed of Vehicle	Multiple Lane Capability?	Additional Lighting Required?	Level of Maintenance Required	Accuracy Rate	Used for Commercial Vehicle Identification?	Expected Life Span of Equipment	Raw Equipment Cost	Availability of the Technology
Full	OCR	N/A	Yes ¹	No	Yes, lighting	75 - 100 ft.	<90 mph	No	Yes	See Note ²	See Note ³	Yes	7-9 yrs.	\$40,000 - \$50,000 All Equipment	COTS, more than 35 vendors
	RFID 100-500 kHz	Transponder	Yes	No	No	6 ft.	25 mph ⁴	No	No	Light to Moderate	Unknown	Yes	10-15 yrs. for Passive Transponder	\$4000-\$10,000 per Reader ~\$20 per Transponder	COTS, large number of vendors
	RFID 900 MHz range	Transponder	No	Yes ⁵	No	300 ft.	120 mph	Yes	No	Light to Moderate	99%+ ⁶	Yes	10-15 yrs. for Reader 4.5-8 yrs. for Active Transponder	\$10,000-\$15,000 per Reader \$20-\$60 per Transponder	COTS, more than 10 vendors
	RFID 35 GHz	Transponder	Yes	No	No	330+ ft.	virtually limitless	Yes	No	Light to none	Unknown	No	1+ yrs. for Transponder	~ \$500 per Reader \$20-\$300 per Transponder	To be determined
	Barcode	Barcode Label	No	No	Yes, laser	2-6 ft.	30 mph	No	Yes	Light	Unknown	Yes	2-3 yrs. for Barcode Label	\$5000 per Reader \$2 - \$4 per Barcode Label	COTS, at least 3 vendors
Manual	Image Capture	N/A	Yes ⁷	Yes ⁸	Yes, lighting	200-250 ft.	60 - 80 mph	No	Yes	Light to Moderate	97%	No ⁹	6 - 9 yrs.	\$5,000 - \$40,000 All Equipment	Commercially available, hundreds of suppliers ¹⁰
	Voice Recognition	N/A	Yes ¹¹	No	No	Varies	Varies	No	No	Light	97-98%	Yes	7-9 yrs.	< \$1000 All Equipment ¹²	Commercially available, many suppliers ¹³

¹ Portable systems require highly trained individuals for proper setup.

² Vendors report maintenance as light to moderate, but some users have noted extensive maintenance.

³ Reports vary. Vendors claim 85% or higher, but evaluations of these systems estimate the accuracy rate is less than 50%.

⁴ With very large antennas, 150 mph is claimed.

⁵ ASTM and IEEE standards.

⁶ At maximum speed (120 mph) and maximum read range (300 ft.), the accuracy rate will be lower.

⁷ Portable systems require highly trained individuals for proper setup.

⁸ Standards are for analog and digital image formats.

⁹ An image capture system for commercial vehicle identification is underway in Walton, Kentucky.

¹⁰ Generally, this technology will need to be adapted to specific applications.

¹¹ The software for a portable system is not currently available.

¹² This amount includes installation of the equipment.

¹³ This technology needs updating and possibly further development for specific applications.

The reported accuracy rate of OCR on license plates varies widely.¹ One reason for this variance is because vendor-reported accuracy rates of 90 percent or higher tend to exclude the population of vehicles that have obstructed or illegible plates. Including these “unreadable” plates, OCR should identify about 85 percent of the vehicles correctly (21). However, State experience shows that the accuracy rate of OCR for commercial vehicles is probably no higher than 35 to 45 percent (23, 24).

This technology has been commercially available for about 10 years, and has been used for toll collection (both free-flow and plaza), vehicular law enforcement (red light running, high occupancy vehicle lanes, etc.), access control, commercial vehicle operations (CVO), border crossings, travel time and origin/destination studies, shipping container tracking, emissions testing, and car parking management. For commercial vehicle identification, the technology has been available for about 5 years. California, Colorado, Indiana, Iowa, Minnesota, Oregon, and Wisconsin have all implemented or attempted to implement license plate readers for commercial vehicle identification (21). These installations have been evaluated by the University of Kentucky and the University of Wisconsin-Madison (23, 24).

From these evaluations, there are several noted areas of concern. The cameras were negatively affected by the weather and the harsh environment of the roadside application. There were reports of periodic lightning strikes and condensation within the camera, as well as alignment and contrast problems. Other issues with regard to the camera included its narrow field of vision and its need for continuous power (for heating and cooling). It was noted by one State that plenty of ramp distance was needed for reading and identification of the vehicle. States have also experienced data transfer and presentation problems, and significant problems with integrating the equipment with WIM scales (23, 24).

Besides the equipment, there are concerns regarding the license plate and the vendors. Obstructed and/or illegible plates are impossible for OCR systems to “read”, and highly reflective plates can give some systems problems. Different font styles, plate formats, and the lack of any standard location for license plates also add to the performance problem (25, 11). With regard to the vendors, there are a limited number working specifically with commercial vehicle identification. In addition, there are currently no standards for this technology.

Optical character recognition technology is commercially available off-the-shelf from more than 35 vendors (25). However, there are some improvements to the technology expected in the future. These improvements include: faster central processing units, all-digital cameras, enhanced software and digitizers, and improved illuminators (21, 22). Vendors also hope that license plates will be standardized, or at least changed (with regard to their design and syntax) to make them more “OCR friendly”. The equipment should have a life expectancy of seven to nine years, and could cost \$40,000 - \$50,000 for a single lane installation (21).

¹See Section 3.4.7 for a discussion of system accuracy.

3.4.2 Radio Frequency Identification (RFID)

Radio frequency identification relies on electromagnetic waves between a transponder and a reader for automatic identification. The transponder, a small device located on the vehicle, is encoded with an identification number. This identification number is typically linked in a database to information about the power unit and/or motor carrier. The transponder may also have additional memory capability, allowing other identifying information (USDOT number, license plate number, etc.) or application-specific data to be programmed into it.

The main components of a basic RFID system include the reader, antenna, transponder, and central processing unit. RFID systems can be grouped into three basic categories, based primarily on the frequency at which they operate. The performance characteristics and equipment costs can vary substantially, so it is worthwhile to examine each category separately.

Inductive (100-500 kHz Range)

Typical “low frequency” transponders are characterized by antennas that are comprised of numerous turns of a fine wire around a coil former. These antennas collect energy from the reader’s magnetic field to power the transponder (26). In most situations, the transponder is mounted under the truck and the reader antenna is a loop placed in the pavement. Low frequency handheld readers have also been developed for mobile systems.

These low frequency transponders can be read from about 6 feet away on vehicles traveling 25 mph or slower (27, 28). Because of this relatively short read range, multiple lane installations require one antenna per lane. The equipment can communicate through most nonmetallic materials, and is very durable under adverse weather conditions (28). Although most of the equipment requires very little maintenance, the pavement antenna can easily be damaged with roadbed movement or water intrusion, so it requires moderate levels of maintenance (10).

Low frequency RFID systems have been deployed for several years for access control, animal identification, and inventory control. They have also been applied for slow speed vehicle identification on some trucks. From these applications, several areas of concern have been noted. Installation of the transponder is somewhat more difficult than for other types of RFID, and the likelihood of losing the transponder is relatively high. In addition, these systems are not as reliable as “high frequency” RFID systems. The slow data rate makes it easy for the system to correlate data to the wrong transponder (10). Electromagnetic noise, such as switched-mode power supplies and video display screens can interfere with the system as well (28).

If the low frequency transponder is powered by the reader, it can be expected to last 10 to 15 years. Transponders that are dependent on an internal battery for power will have much shorter life spans. Total cost for the roadside equipment (excluding the central processing unit) is in the range of \$4000-\$10,000. The transponders are about \$20 each (10). This technology is commercially available off the shelf from a wide range of suppliers (26).

Electric Coupling (900 MHz Range)

These “high frequency” systems rely on the electric field propagation properties of radio communication to convey energy and data from the reader to the transponder and data from the transponder to the reader (26). Antennas for these systems are typically mounted on the side of the road and positioned over the lane of traffic. The readers are generally not suitable for mobile application, although portable readers have been tested and deployed on a small scale (32). The transponder is typically battery-powered and mounted on the windshield of the vehicle.

Both wide area and lane-based high frequency RFID systems have been developed. The lane-based systems are designed to read tags within a few feet of the reader. Wide area transponders can be read from as far away as 300 feet, although the typical range is 30 to 150 feet. Due to the fast data transfer capabilities of the technology, it can communicate with transponders on vehicles traveling up to 120 mph. A single reader and antenna can be used to identify multiple lanes of commercial vehicles (29).

High frequency RFID systems also perform extremely well under harsh weather conditions. Generally, the transponder is mounted inside the vehicle, although there are external bumper or rooftop transponders available from some vendors. Proper transponder operation is highly dependent upon correct transponder mounting and clear line of sight to the overhead/roadside antenna. The transponder requires little or no maintenance, and the remaining equipment requires light to moderate levels of maintenance. Suppliers and users of the technology agree that accuracy rates can exceed 99 percent (10, 29, 30, 31).²

High frequency RFID systems have been deployed for toll collection (free-flow and plaza) and enforcement, commercial vehicle electronic screening, international border crossings, access control, and intermodal freight identification. The technology has been used for commercial vehicle identification for over 5 years. Jurisdictions that currently use these systems for commercial vehicle identification include: Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Illinois, Kentucky, Michigan, Mississippi, Montana, New Mexico, New York, Ohio, Ontario, Oregon, Tennessee, Utah, Washington, and Wyoming. High frequency RFID systems for electronic screening purposes have been evaluated by the University of Kentucky (33).

When implementing a high frequency RFID system, compatibility and interoperability among systems should be considered. Although several vendors currently sell this technology, their systems are, for the most part, proprietary and incompatible. Substantial effort has been expended developing proposals and drafts for the physical (Layer 1), data link (Layer 2), and message set (Layer 7) standards. However, the balloting (i.e., approval) process has produced mixed results, and there may be considerable delay in bringing standard-compliant technology to the marketplace.

Other important issues include development of a transponder registry and the maintenance of unique transponder identification numbers. Data integrity is also important, since transponders

²See Section 3.4.7 for a discussion of system accuracy.

are easy to move from vehicle to vehicle. To address the issue of data integrity, many current systems employ technologies (such as vehicle classifiers or video imaging) for independent verification and/or spot checking of transponder data.

High frequency RFID technology is commercially available off-the-shelf from more than ten vendors, although some changes to the technology are expected in the future. The protocol for this technology is expected to be standardized, possibly driving down the cost.

An increase in the frequency range is also a possibility. The Federal Communications Commission (FCC) has already been petitioned for the 5.85-5.925 GHz frequency band (32). If this petition is successful and the technology migrates to this frequency band, faster data transfer rates can be expected, along with a possible increase in cost.

Current readers have a life expectancy of about 10 to 15 years, while the battery-powered transponder typically lasts 4.5 to 8 years. The cost of a reader is typically \$10,000 to \$15,000, while the transponder costs \$20 to \$60 (29,30).

“Electronic” Doppler Shifting, 35 GHz Range

This system utilizes a concept of “electronic” Doppler shifting to generate a frequency shifted signal in response to an interrogation signal. The high frequency operation of the system permits the tags to be much smaller than a conventional transponder (as small as 5 mm in diameter). The transponders can be installed outside or inside the vehicle. Conventional police/sport radar guns can be used as the reader, making the system ideal for mobile applications (34).

The reader can communicate with the transponder from a distance of more than 330 feet and can capture data on vehicles traveling virtually any speed. The system’s high data transfer rate and wide range allow it to work on multiple lanes of traffic. As with other RFID systems, the equipment is extremely durable and can withstand extreme weather conditions. Vendors report that maintenance for these systems is light (34).

This technology has been deployed for more than 10 years for classified government programs involving vehicle identification, although it has not been specifically used for commercial vehicle identification. Because the testing of this technology is classified, there is limited information on the equipment characteristics and performance specifications (34).

This technology is not currently commercially available and is manufactured by only one vendor. In the future, it is expected that this technology will migrate into high-security applications. The transponder has a life expectancy of about one year if mounted outside the vehicle, and two to three years inside the vehicle. The transponder cost could range from \$20 to \$300, depending on the number purchased and the size of the total market. The cost of a roadside reader is estimated to be \$500 (34).

3.4.3 Barcode

A barcode system is composed of a barcode label, a reader (or scanner), and a data storage or transmission system. The label is made up of patterns of varying-width light and dark elements (typically bars) that represent numbers, letters, or punctuation symbols. For vehicle identification, this label is typically about 3 3/4" x 2 1/2" and is attached to the side window (12). As the vehicle passes by the reader, the label is illuminated by an IR or visible laser. The dark bars absorb the light and the light bars reflect it back to the reader. This pattern is then decoded by the use of algorithms (20). The barcode label could be linked in a database to any common identifier on the vehicle.

Although some barcode readers require contact with the label, vehicle identification systems can read labels from 2 to 6 feet away on vehicles traveling up to 30 mph. Multiple readers would be necessary for multiple lane. Safety regulations for lasers (as published by the Center for Devices and Radiological Health) must be met when deploying these systems. While there are currently no standards for applying this technology to commercial vehicle identification, there are standards for non-vehicle applications (12).

As a rule, barcodes require very little maintenance. However, dirt, grime, or snow can obscure the barcode and interfere with commercial vehicle identification, particularly in wet conditions. Maintenance of the remaining equipment is light, and includes cleaning of the glass face plate of the reader. Portable barcode systems for vehicle identification are not currently available, but are being developed (12).

Barcode technology has been used for vehicle access control, toll collection, and railcar identification. It has been used on commercial vehicles in toll applications, but it has not been used for commercial vehicle screening (12).

Barcode systems for vehicle identification have never been formally evaluated, so there is no available documentation on their accuracy. Both vendors and users of the technology have been quite satisfied with the results, estimating the accuracy to be very high (12, 35, 36).³ It should be noted that most uses to date have been in warmer climates, where there is little to no problem with snow or grime buildup, conditions that could be a serious impediment for nationwide deployment. Other concerns with the technology include the ease with which the barcode label can be forged and the label's sensitivity to weather and dirt (37).

Barcode technology for vehicle identification is a fully mature technology that is commercially offered by at least three vendors. Adjustments may need to be made for specific commercial vehicle use. The barcode label can be expected to last two to three years, but is usually only warranted for one year. The labels typically cost from \$2 to \$4 each, but may cost considerably less in bulk. The barcode readers are about \$5000 each (12).

³See Section 3.4.7 for a discussion of system accuracy.

3.4.4 Image Capture

Image capture is the process of obtaining an image of a vehicle for identification purposes. Unlike OCR, identification of the vehicle is not automated, but is dependent on a human. Any identifier that can be captured in an image of the vehicle (such that the identifier is legible) can be used with this type of identification system.

A single-lane application of image capture technology will usually have a trigger, an illuminator, cameras (one or more depending on the application), a central processing unit, and a storage or transmission system. Multiple lane applications may require additional triggers, illuminators, cameras, and central processing units (38). There is no supplemental equipment required on the vehicle, but a human is needed to decipher the captured information. These systems can be portable, but require intensive training for proper setup and are better suited for fixed applications (21). Maintenance for the equipment usually involves monthly cleaning of the cameras, lighting, triggers, and hard drive space (22).

Cameras are able to capture usable images of vehicles traveling up to 60-80 mph, from a distance of up to 250 feet. Under certain conditions, additional visible or IR lighting is needed in order to obtain clear and legible images. This additional lighting can create a safety hazard if it is distracting to drivers (38, 39). Standards have been developed for analog and digital image formats (39).

Accuracy rates for image capture systems can be expected to be higher than for OCR systems.⁴ OCR systems involve not only the capture of an image, but also the computer's interpretation of that information. Image capture systems require only the capture of a clear image with the appropriate identifying information (although they are, of course, subject to human error). For commercial vehicle identification, the accuracy rate of this technology is still unknown. However, an evaluation of this technology for enforcement of high occupancy vehicle lanes found the technology to successfully capture the correct information 97 percent of the time (40).

Image capture technology has been applied for vehicular law enforcement (railroad crossings, red-light running, and speed limits), crash testing analysis, CVO surveys, access control, and commercial parking and revenue control (22, 38, 39). Although there has not been specific use of this technology for commercial vehicle identification, Kentucky is deploying such a system this year. That system will be used to capture an image of the license plate and the side of the power unit (USDOT number, Kentucky Unit (KYU) number, company name, etc) on vehicles that are detouring around a nearby weigh station.

Areas of concern for this technology are similar to those of OCR technology. For instance, the camera can be negatively affected by adverse weather conditions and the harsh environment of a roadside application. For the vehicle, different power unit styles and the lack of specific national standards for the location of identifying information will complicate the image capture process. Finally, one of the biggest areas of concern for this technology is its reliance on

⁴See Section 3.4.7 for a discussion of system accuracy.

human intervention. This type of system will require a person to review the images and identify them manually.

This technology is commercially offered by hundreds of vendors, but would probably require some general adaptation for this application (25). Systems in the future will have faster processing units, all digital cameras, and improved illuminators (22, 38, 39). The field equipment for this technology has a life expectancy of six to nine years, and will cost anywhere from \$5,000 to \$40,000, depending on the application (21).

3.4.5 Voice Recognition

Voice recognition technology converts human speech into electrical signals and transforms these signals into coding patterns with assigned meanings. For a simple voice recognition system, the only equipment required is a microphone headset, a central processing unit, and a voice recognition sound card. The system is capable of fixed and mobile installations, although software for mobile applications would require a minimal amount of development (41, 42).

Voice recognition technology is dependent on human intervention for identification, and is one of the few technologies that is oriented to the way a human works. There are speaker-independent systems which do not require intensive voice training prior to using the device (15 to 45 minutes), and speaker-dependent systems which have to be trained by an individual to recognize his or her specific voice patterns (3 to 4 hours) (42,43).

Voice recognition technology could be used as a stand-alone system or to supplement other technologies, like an image capture system. In any event, many performance specifications, like the maximum distance from the vehicle or the speed of the vehicle, will be dependent on the human using the system. In addition, the identifier used with such a system will be dependent on what is visible and legible to the human operator. Such a system might require supplemental lighting to aid the human operator, depending on the specific application. If additional lighting is used, the brightness of that light would have to be considered for the safety of the drivers. There are currently no standards for this technology (42).

All the equipment can be stored in an enclosed and controlled environment. In turn, temperature and weather extremes have no effect on the equipment. This also results in very little maintenance required for the system.

Voice recognition has been used for the identification of damage on railway cars and the inspection and identification of commercial vehicles. With regard to commercial vehicle identification, Nebraska and Washington have used this technology with the ISS system. Small-scale evaluations performed by FHWA, Signal Processing Systems, and Nebraska enforcement officers have concluded that the technology is extremely accurate (approximately 97 to 98 percent) in decoding human speech (43).⁵

⁵See Section 3.4.7 for a discussion of system accuracy.

The lack of additional funding has impeded further deployment and evaluation of this technology. States with experience in this technology have noted the need for a new (non-proprietary) sound card, a noise cancellation stick-microphone (as opposed to a headset microphone), and an upgraded system built around the new ISS software (40). Officers have also noted that non-native English speaking individuals may encounter problems with these (speaker-independent) systems (43).

The technology is commercially available, but may require further development for specific applications. There are several vendors working with voice recognition technology, but a limited number working specifically with commercial vehicles. The technology is considered fully mature with no changes expected in the near future. The equipment can be expected to last about seven to nine years and costs less than \$1,000 for the equipment and installation. Total system cost, including training, is less than \$5,000 (42).

3.4.6 Other Technologies

There are other technologies that were considered for this study, but not included in the comparison matrix. These technologies are technically capable of vehicle identification, but for various reasons are not currently appropriate for this type of application.

Global Positioning Systems (GPS) with Satellite or Radio Communications

Global positioning systems provide specially coded satellite signals that can be processed in GPS receivers, enabling the receivers to compute position, velocity, and time. More and more motor carriers are installing these GPS receivers on their vehicles for tracking purposes. In conjunction with GPS systems, two-way communication is usually established between the vehicle and the dispatch center by radio or satellite communications. Currently deployed systems are used to inform customers of delivery times and manage fleet logistics, but they could also be used to inform enforcement officers of the position and identity of an approaching truck. Such systems would be dependent on an agreement by the motor carrier to voluntarily inform enforcement officers of their presence and impending arrival at enforcement locations (45). Furthermore, they represent a significant investment by the motor carrier and could be prohibitively expensive to deploy in all vehicles.

Infrared (IR)

Limited-distance IR transmission can be used to provide vehicle identification information for automated toll-taking (46). A scanner, similar to those used in barcode systems, is used to communicate with a transmitter located on the vehicle. These IR triggering and communication techniques have very short operating ranges and have had limited success for vehicle identification (47). There are no currently-known IR products that are viable for this application (10).

Contact Memory

Contact memory tags are small electronic identification and data storage devices that were designed to be attached to objects to identify and retain information specific to those objects. These devices can be thought of as small, durable computer diskettes capable of storing data files. These files are accessed via a momentary contact using a simple probe connected to a personal computer (20). Because this technology requires contact between the probe and the tag, it does not appear to be practical for automated roadside identification of commercial vehicles.

3.4.7 Discussion of System Accuracy

In assessing the performance of various technologies for commercial vehicle roadside identification, it is useful to be able to compare the “accuracies” of those technologies. However, this must be done with care, because accuracy rates reported by vendors and system users may have different meanings for different technologies and/or different applications. For the purpose of this report, the “accuracy rate” refers to the percentage of vehicles correctly identified out of all vehicles “attempted.” For an OCR system attempting to read license plates, all vehicles passing the system are considered to be “attempted,” because all vehicles are supposed to have license plates and are candidates for the system. This would also be true for an image capture system. For an RFID or barcode system, the “attempted” vehicles would be those equipped with the proper transponder or barcode label. This is an important distinction when comparing one technology to another. For example, an OCR system with a 40 percent accuracy rate would correctly identify four times as many vehicles as an RFID system with a 100 percent accuracy rate, if only ten percent of the passing vehicles had transponders.

As defined in this report, the accuracy rate can be affected by many factors, and does not necessarily reflect the full capability of the technology. For example, when an OCR system fails to correctly identify a vehicle, it could be the result of the license plate being missing, improperly positioned, damaged, or obscured (by dirt, snow, etc.). In many of these cases, the license plate is illegible even to a human observer, so the technology itself is not at fault. However, such factors do significantly affect performance in the real world. The performance of OCR systems is also affected by the variety of license plate designs that must be read. When plates vary with regard to number of digits, fonts, colors, contrast, and layout (which is the case for commercial vehicle plates), the processing requirements of the OCR system increase exponentially. This is another example of how real-world conditions can prevent a technology from performing at its full potential.

3.5 MOTOR CARRIER ACCEPTANCE

No assessment of alternative technologies for roadside identification of commercial vehicles would be complete without some discussion of motor carrier acceptance. While public agencies often have the capability to force requirements on motor carriers, with or without their approval, this approach usually results in a combative, “us versus them” climate, which is not conducive to achieving enforcement goals. On the other hand, when motor carrier enforcement is viewed as a cooperative venture of public agencies and the motor carrier industry, then all major decisions regarding future directions for enforcement programs should be made in full cooperation with the motor carrier community.

The issue of motor carrier endorsement and acceptance is particularly germane for roadside identification systems. Over the past several years, various motor carrier representatives and associations have voiced concern over the potential privacy and data security issues raised by automated roadside identification technologies. These concerns have surfaced in several forums (most notably, in ITS America's CVO Committee), and they have resulted in adoption of a set of overall guiding principles and "Fair Information" principles by ITS America (48).

It is worth noting that roadside identification technology also offers significant potential to help achieve many of the outcomes desired by the trucking community. These include: leveling the playing field, concentrating enforcement efforts on unsafe or illegal carriers, reducing record-keeping and reporting requirements, and reducing tax evasion. Unfortunately, these positive aspects tend to receive much less attention than the fears and concerns.

One of the key principles that is consistently promoted by the motor carrier community is that participation by motor carriers in ITS programs should be voluntary. This is a significant issue for roadside identification technologies, since the goal of such technologies is to be able to automatically identify all commercial vehicles at the roadside. Any system that can identify all trucks, is, by definition, non-voluntary. So, the question becomes, "Are some non-voluntary systems more acceptable than others?"

Preliminary discussions with motor carrier representatives have indicated that some technologies may, in fact, be more acceptable than others. For example, many motor carrier representatives have expressed strong opposition to the idea of mandatory transponders, while far less opposition has surfaced regarding deployment of OCR systems. (This is not meant to imply that there is no opposition to OCR systems.) This difference is quite interesting when one considers that the two technologies basically do the same thing, i.e., they automatically identify the company/vehicle using a truck-mounted identifier and a roadside "reader." They also have the same potential for widespread deployment, additional data collection, and possible abuse. Thus, it appears that the objection to mandatory transponders is not so much an objection to the functionality that they provide, but to something else. Unfortunately, there is very little information available on what this "something else" might be.

The issue of motor carrier acceptance of roadside identification technologies is poorly understood. It has been much discussed in various national forums, but these discussions have tended to be superficial and have focused almost exclusively on the negative aspects. They have generally consisted of repeating broad principles without questioning what they really mean or why they are held to be true. These questions are beyond the scope of this study, but they are critical questions for those attempting to develop a vision for the future of commercial vehicle enforcement in the United States.

4.0 CONCLUSIONS

4.1 THE NEEDS ASSESSMENT

4.1.1 Commercial Vehicle Identification

States are clearly in need of a quicker, more efficient way to identify commercial vehicles at both fixed and mobile enforcement locations. Because the number of vehicles being checked represents a relatively small percentage of the total traffic stream, it is essential that enforcement personnel make good decisions on which vehicles to stop. Enforcement resources must be focused on high-risk carriers and vehicles. This is particularly true for fixed inspection/weigh stations, where truck volumes tend to be high and the percentage of violators tends to be low. Under those conditions, an enforcement effort that is not somehow “focused” on high-risk vehicles will be highly inefficient. For temporary roadside locations and roving patrols, truck volumes are generally lower and the percentage of violators in the traffic stream tends to be higher, so the need for “targeting” is less critical. However, even at these locations, there is potential for substantial benefit from effective targeting of resources.

The benefits of automated roadside identification of commercial vehicles accrue not just to the public agencies responsible for roadside enforcement. Motor carriers benefit from more efficient processes, less delay, reduced paperwork requirements (possibly), and a more level playing field. The general public benefits from improved roadway safety and reduced damage to the highway infrastructure (with the associated costs).

The “ideal” technology for commercial vehicle identification should be accurate, reliable, portable, automated, and capable of slow and/or high-speed identification. However, a technology that falls short of the ideal can still have significant potential. For example, a system without high-speed capability can still be applied for screening on a weigh station ramp or at a temporary roadside facility. A non-portable system can still be well-suited to screening (ramp or mainline) at a fixed enforcement facility. Of course, systems designed for use by roving patrols will need to be located in the enforcement vehicle and should be easy to use while the vehicle is in operation.

4.1.2 The Identifier

When considering identifiers for commercial vehicles, a key question is, “What do we need to identify.” Specifically, do we need to identify the specific power unit or the motor carrier for which the vehicle is operating? Or, is it necessary to identify both? For current conditions, the greatest value comes from identifying the motor carrier. Safety-related statistics, such as safety ratings, out-of-service percentages, and ISS scores, are tabulated for each motor carrier. In addition, fuel taxes and other mileage-based taxes are generally the responsibility of the motor carrier. Thus, identifying the motor carrier is extremely helpful in concentrating enforcement resources on high-risk carriers. However, there are also pieces of information that cannot be obtained from the carrier’s identification. The inspection history of a specific vehicle, for example, including any current out-of-service conditions, can only be obtained if the power unit is

identified. In addition, certain credentials-related information, such as the registration and taxes for a given vehicle (and the registered legal weight), can only be checked at the power unit level. Thus, it appears that, in order to fully check a vehicle's safety and credentials status, it is necessary to identify both the motor carrier and the specific power unit.

One approach to this problem is to associate each power unit with a motor carrier in a database. Then, whenever a power unit is identified, the corresponding carrier identification can be obtained from the database. This is a good theoretical concept, but is complicated by the fact that many power units change carriers frequently, even on a daily basis. Thus, in the near term, it is unlikely that accurate power unit-carrier linking data will be available, so it will continue to be necessary to obtain carrier identification directly from the vehicle. (Of course, when vehicles change carriers frequently, even the carrier information displayed on the vehicle is of questionable accuracy).

There is a need for a common identifier (or identifiers) for carrier and vehicle identification. The same identifier can be used for fixed and mobile applications. The USDOT number is the best available identifier for interstate motor carriers, and now includes many intrastate carriers as well. The license plate (State plus number) is the best available identifier for power units. The license plate could be substantially improved as an identifier if the format was standardized throughout the United States (or North America). Other identifiers, such as the ICC, VIN, and Carrier Name, all have major shortcomings. Transponder and barcode systems have the capability of linking the carrier and power unit identification in a database, but face the problem (as discussed in the previous paragraph) of vehicles that frequently change carriers.

Currently, the carrier identifier (i.e., USDOT number) and the power unit identifier (i.e., license plate) are displayed in two different locations on the vehicle. This greatly complicates the design of any system attempting to read both identifiers.

4.2 TECHNOLOGY OVERVIEW

4.2.1 Optical Character Recognition (OCR)

Optical character recognition is a technology that has been deployed for several years with proven capabilities. Its application for commercial vehicle identification, however, is relatively new. This application of the technology has had limited success mainly due to its own unique problems specifically related to the identifier. Since each jurisdiction issues and regulates its own commercial vehicle license plates, there are extreme variations in the font type and size, style, color, contrast, and location of the plate. The federally required identifiers (USDOT number, ICC number, and the carrier name) have some commonality among commercial vehicles, but still vary in appearance and location. Also, some States require additional information to be displayed. This lack of uniformity complicates an OCR system.

Although an OCR system does not require additional equipment on the vehicle for identification, it does require specific standards for the identifier and how it is displayed. For optimal performance, the location and appearance of the identifier would have to be standardized for all commercial vehicles. However, even with stricter requirements, it would not be possible to

identify every vehicle using OCR. Obscured or damaged identifiers, inclement weather, and dirty, roadside environments will always be an obstacle for these types of systems. The strengths and weaknesses of OCR technology are summarized in Table 3.

Table 3: Strengths & Weaknesses, OCR

Optical Character Recognition (OCR)	
<i>Strengths</i>	<i>Weaknesses</i>
1. No additional equipment required on vehicle	1. Single system is not capable of multiple lane identification
2. Any visible and legible identifier on vehicle may be used	2. Lighting required for nighttime operation
3. Commercially available by many vendors	3. Not well suited for mobile applications
4. High or slow speed identification	4. Application to commercial vehicles is relatively new
5. Deployed for more than 10 years	5. Dependent on condition/location of identifier
6. Minimal human intervention required	6. Negatively affected by harsh weather and roadside environment
	7. No standards

4.2.2 Radio Frequency Identification (RFID)

Radio frequency identification is a proven technology that has been used for vehicle identification for several years. These systems are rugged, durable, and extremely accurate, making them well-suited for most weather conditions and the roadside environment. Perhaps the biggest obstacle for this technology is the requirement for an additional electronic device on the vehicle (and the strong resistance of the motor carrier community to any such device being mandated

Inductive (100-500 kHz)

Inductive RFID is not well suited for vehicle identification. While it could potentially be used for slow-speed applications only, it has significant disadvantages (and no significant advantages) when compared to high-frequency RFID systems. The strengths and weaknesses of inductive RFID systems are summarized in Table 4.

Table 4: Strengths & Weaknesses, Inductive RFID

Inductive Radio Frequency Identification (RFID)	
<i>Strengths</i>	<i>Weaknesses</i>
1. Line-of-sight not required	1. Single system is not capable of multiple lane identification
2. Any identifier may be used/linked to transponder	2. Short read range
3. Commercially available by many vendors	3. Additional equipment required on vehicle.
4. Used on commercial vehicles for many years	4. Slow-speed applications only
5. Durable in harsh weather/roadside applications	5. Potential for low reliability
6. Mobile systems exist	6. Electromagnetic noise interference
7. Light to moderate maintenance	7. No standards
8. Minimal human intervention is required	8. Transponder registry
	9. Unique transponder numbers

Electric Coupling (900 MHz)

From the standpoint of technical feasibility, this appears to be the best technology currently available for automated roadside identification of commercial vehicles. These systems have been successfully deployed for several years, and they have proven to be highly accurate and reliable. The technology is affordable, suitable for slow and high-speed applications, and capable of identifying multiple lanes of traffic.

Drawbacks to this technology, from a technical standpoint, include the lack of national standards and interoperability (although progress is being made on this front), and the lack of readily available portable readers. From an institutional standpoint, the barriers are more substantial. The issue of motor carrier acceptance and the proprietary nature of some existing transponder-based systems offer significant challenges to the vision of nationwide deployment. A summary of the strengths and weaknesses of electric coupling RFID systems can be found in Table 5.

Table 5: Strengths & Weakness, Electric Coupling RFID

Electric Coupling Radio Frequency Identification (RFID)	
<i>Strengths</i>	<i>Weaknesses</i>
1. Standards nearly complete	1. Readers not readily available for mobile applications
2. Line-of-sight not required	2. Few vendors selling compatible technology
3. Any identifier may be used/linked to the transponder	3. Additional equipment required on vehicle
4. Commercially available by several vendors	4. Transponder registry
5. Durable in harsh weather/roadside applications	5. Unique transponder numbers
6. Long read ranges	6. Institutional barriers to interoperability
7. Slow and high-speed applications	
8. Capable of multiple lane identification	
9. Minimal human intervention required	
10. Light to moderate maintenance	
11. High accuracy rates	
12. Deployed by multiple States	

Doppler Shifting (35 GHz)

Although there is limited information available on Doppler shifting RFID, it seems to offer a great deal of potential. These systems have all the technical strengths of electric coupling systems, without some of the weaknesses. However, once deployed, there will be many of the same institutional barriers for Doppler shifting RFID as with electric coupling RFID. Because of the limited experience with this technology, it needs further evaluation on a small population of commercial vehicles prior to widespread deployment. A summary of the strengths and weaknesses of Doppler shifting RFID can be found in Table 6.

Table 6: Strengths & Weaknesses, Doppler RFID

Doppler Shifting Radio Frequency Identification (RFID)	
<i>Strengths</i>	<i>Weaknesses</i>
1. Mobile systems are available	1. One vendor
2. Line-of-sight not required	2. Availability of technology uncertain
3. Slow and high-speed applications	3. No standards
4. Long read ranges	4. Additional equipment required on vehicle
5. Capable of multiple lane identification	5. Limited use/evaluation
6. Any identifier may be used/linked to the transponder	6. Never used for commercial vehicle identification
7. Minimal human intervention required	7. Transponder registry
	8. Unique transponder numbers

4.2.3 Barcode

Barcode technology is fully mature and proven technology, but its application to vehicles is relatively new. Unfortunately, this technology shares many weaknesses (but not strengths) displayed by other technologies. Like OCR systems, barcode technology will be unable to identify every vehicle because of obscured identifiers (barcode labels), inclement weather, and dirty, roadside environments. Like RFID systems, additional equipment is required on the vehicle for identification. In addition, the technology would only be applicable for slow-speed identification purposes. A complete list of the strengths and weakness of barcode technology can be found in Table 7.

Table 7: Strengths & Weaknesses, Barcode

Barcode	
<i>Strengths</i>	<i>Weaknesses</i>
1. Mature technology	1. Limited number of vendors
2. Light maintenance	2. Additional equipment required on vehicle
3. Any identifier may be used/linked to barcode label	3. No standards
4. Commercially available	4. Slow-speed applications only
5. Minimal human intervention required	5. Short read range
	6. Single system is not capable of multiple lane identification
	7. Line-of-sight required
	8. Additional lighting required
	9. Negatively affected by harsh weather and roadside environment
	10. Minimal use on commercial vehicles
	11. Mobile systems not currently available

4.2.4 Image Capture

Although this technology is not automated, it could be deployed to supplement current commercial vehicle enforcement activity or as the first phase of an OCR system. Image capture technology shares many of the same strengths and weaknesses of OCR technology. Image capture technology is dependent on the appearance, and specifically the location of the identifier. Like OCR technology, image capture will not be able to identify every vehicle because of obscured identifiers, inclement weather, and dirty, roadside environments. However, with human intervention, image capture systems can accurately identify a higher percentage of commercial vehicles than OCR systems. A list of the strengths and weaknesses of image capture technology can be found in Table 8.

Table 8: Strengths & Weaknesses, Image Capture

Image Capture	
<i>Strengths</i>	<i>Weaknesses</i>
1. No additional equipment required on vehicle	1. Human intervention required
2. Any visible and legible identifier on vehicle may be used	2. Not well suited for mobile applications
3. Commercially available by several vendors	3. Single system is not capable of multiple lane identification
4. Slow or high-speed applications	4. Never used for commercial vehicle identification
5. Standards set for video image format	5. Negatively affected by harsh weather and roadside environment
6. Long read range	6. Dependent on condition/location of identifier
7. Light to moderate maintenance	
8. High accuracy rate	

4.2.5 Voice Recognition

Voice recognition technology has a great deal of potential to enhance current commercial vehicle enforcement activity. Although this technology may be used at fixed or temporary locations, these systems are ideally suited for in-vehicle applications. Voice recognition systems are relatively simple and have been successfully applied to commercial vehicles. A list of the strengths and weaknesses of this technology can be found in Table 9.

Table 9: Strengths & Weaknesses, Voice Recognition

Voice Recognition	
<i>Strengths</i>	<i>Weaknesses</i>
1. No additional equipment required on vehicle	1. Human intervention required
2. Any visible and legible identifier on vehicle may be used	2. No standards
3. Commercially available by several vendors	3. Single system is not capable of multiple lane identification
4. Ideal for in-vehicle applications	4. Some development required for mobile applications
5. High accuracy rate	
6. Relatively simple installation	
7. Maintenance is light	
8. Used and evaluated on commercial vehicles	
9. Not affected by adverse weather	
10. Fully mature	

4.3 SUMMARY OF TECHNOLOGY CONCLUSIONS

This study identified eight different technologies that offered potential for use to provide roadside identification of commercial vehicles. Three of these technologies (GPS, IR, and contact memory) had clear shortcomings that resulted in them being given only a cursory assessment. The other five technologies, listed below, were assessed more fully.

- Optical Character Recognition (OCR)
- Radio Frequency Identification (RFID)
- Barcode
- Image Capture
- Voice Recognition

Of these technologies, only the first three are capable of fully automated identification. The other two are best described as tools to assist a human observer in the vehicle identification process. Thus, the evaluation of alternatives for automated identification comes down to a comparison of three technologies.

The principal advantage of OCR is that it can be used to read existing identifiers on the vehicle. The principal disadvantage is that the performance (with those existing identifiers) is

quite poor. The primary advantage of RFID is that it provides extremely high performance levels. The primary disadvantage is that it requires an additional electronic device on the truck. Barcode cannot offer the high performance of RFID, nor can it work with existing identifiers. It can provide a higher performance level than OCR, and the additional device required on the truck is simply a label, rather than an electronic device. However, barcode technology is not capable of high-speed vehicle identification.

From this analysis, it is reasonable to conclude that there are two preeminent technologies for automatic identification of commercial vehicles at the roadside: RFID and OCR. Both of these technologies are commercially available, and both are capable of performing fully-automated, slow and high-speed, roadside identification. Each technology has its advocates, and it can be argued that these two technologies are “competing” for the market of commercial vehicle identification. In a sense, one of them is unnecessary, but we do not yet know which one. From a simplistic standpoint, if we can expect all commercial vehicles to have RF transponders in the near future, then there is no need to invest in sophisticated systems designed to read USDOT numbers or license plates. On the other hand, if OCR systems will soon be able to reliably identify all commercial vehicles, then there is no need to equip millions of trucks with transponders. This creates a dilemma of sorts for public agencies, who do not wish to invest in technology that will quickly become obsolete or unnecessary.

Radio frequency identification and OCR are similar in some respects. Both require a roadside “reader,” and both require something on the truck. In the case of RFID, the “something” on the truck is an additional device, a transponder. For OCR, the “something” on the truck is an identifier that is already there, such as a license plate or USDOT number. However, with current technology, these on-vehicle identifiers have proven inadequate to provide satisfactory results. Therefore, whatever technology is chosen, we need to add something to the truck. The question to be answered is, “What do we add to the truck?” Do we add an electronic device, or do we add an improved “label” to get better performance from OCR?

There are three major factors that should influence the answer to these questions. One is cost. Which technology can be deployed most economically? Another is performance. Which technology offers the best performance for our investment? The third is motor carrier acceptance. Which technologies are acceptable to the motor carrier community and which are not?

4.3.1 Cost

There are approximately 800 fixed commercial vehicle monitoring facilities (i.e., weigh stations and ports of entry) in the United States, as well as approximately 1,850 mobile enforcement teams (49). There are approximately 3 million registered commercial vehicles (50). Thus, there are about 3750 commercial vehicles for every weigh station. This is an important consideration when considering investments in weigh station equipment versus on-vehicle equipment.

A typical OCR system installed at an enforcement facility might cost around \$60,000 (for the camera, triggers, lighting, computer, software, and installation). An RFID system to

accomplish the same function (reader, computer, and installation) might cost \$20,000. Assuming that we wished to deploy such systems throughout the U.S. (one at every fixed facility and an additional 800 mobile/temporary sites), the total price tag would be \$96 million for OCR versus \$32 million for RFID. The cost for equipping 3 million trucks with transponders at \$25 each would be \$75 million. Thus, the total cost for nationwide deployment of RFID, including the truck-mounted transponders, would be about \$107 million, compared to \$96 million for nationwide deployment of OCR. These are, of course, ball-park figures, and they do not consider the ongoing costs of maintenance, operations, and periodic replacement of equipment.

4.3.2 Performance

Based upon deployments to date, the performance of OCR systems cannot compare to the performance of RFID. Radio frequency identification systems routinely achieve accurate read rates exceeding 99 percent. For commercial vehicle applications, the best observed performance for OCR has been 35 to 45 percent. Of course, this is not entirely the fault of the technology. Optical character recognition systems are dependent on legible displays of identification numbers which are consistently located and formatted. Where these conditions do not exist, the OCR system is unable to perform its designated function.

With substantial improvements to the way information is displayed on commercial vehicles, we could expect significant improvements in OCR performance, probably achieving 80 percent accuracy (give or take 10 percent). As technology continues to improve, the performance may approach or exceed 90 percent. However, it is not likely that OCR systems will approach the performance levels of RFID within the foreseeable future.

4.3.3 Motor Carrier Acceptance

In light of the strong concerns of the motor carrier industry over data privacy and voluntary participation, decisions on technology cannot be made on a strictly technical or cost-benefit basis. A critical factor that must be considered is acceptance of a particular technology by the trucking community. Strong resistance has been voiced by motor carriers to the idea of mandatory transponder-based systems. This resistance does not appear to be as strong with regard to OCR systems. Thus, OCR systems may have a major advantage in the realm of motor carrier acceptance.

Decisions regarding the types of technologies to be used have enormous implications for the future of commercial vehicle enforcement in North America. Therefore, the issues surrounding motor carrier resistance to electronic monitoring (and specifically to RFID) need to be better understood. With such an understanding, it will be possible to make rational decisions that benefit all stakeholders. Through open dialogue and continuous involvement by the trucking community, it should be possible to implement roadside identification technologies in such a way that the objectives are achieved while maintaining data privacy and fair information principles.

5.0 RECOMMENDATIONS

There are many steps that can be taken to accelerate the development and implementation of effective roadside identification technologies for commercial vehicles. Some of these are designed to foster development of promising technologies. Others are targeted toward creating simpler and more uniform requirements related to commercial vehicle identification.

Technologies:

1. As the most accurate and reliable technology currently available for commercial vehicle roadside identification, RFID should continue to be promoted and supported. This should include continuing efforts to pursue standards and promote interoperability across jurisdictional and functional lines.
2. A controlled test of OCR technology should be conducted to evaluate the relative performance levels for reading USDOT numbers on doors versus reading commercial vehicle license plates. This test should include an evaluation of alternative designs/locations of the door display and the license plate for optimum readability. It should also contrast the performance level for the optimized identifiers with the performance level for currently existing identifiers.
3. Using the results of the controlled test (recommendation #2) and the selected, optimized identifier, OCR equipment should be installed and thoroughly evaluated at one or more locations to determine the real-world performance levels for the standardized plate/label.
4. Testing of voice recognition technology for enforcement applications should continue.
5. An assessment should be conducted into the feasibility (and level of user support) of replacing current manual identifiers (e.g., license plates and numbers on doors) with a transponder or incorporating a transponder into a current identifier (such as the license plate).

Identifiers and Procedures:

1. A unique, user-friendly identifier should be established for all motor carriers that operate trucks in the United States. The USDOT number serves this purpose for all interstate carriers, but does not include most intrastate carriers. Thus, the simplest way to carry out this recommendation would be to accelerate current efforts to assign USDOT numbers to all carriers.
2. A unique, user-friendly, vehicle-specific identifier should be established for all commercial vehicles that operate in the United States. There is currently no such identifier available. The license plate (State of issue plus number) can serve this purpose, but would be much more user-friendly if States could agree on a standard format (see recommendation #5).

3. Federal requirements for displaying identifiers on power unit should be revised as follows. The only identifiers required to be displayed should be a single, unique carrier identification (per recommendation #1) and a single, unique vehicle identification (per recommendation #2). Both these identifiers should be displayed in the same location (such as the side of the power unit), so that all pertinent information can be captured in a single view. The format of the display (e.g., font, size, contrast, etc.) should be specified to achieve optimum readability by OCR systems.
4. Consensus should be sought among States to conform to the Federal requirements (per recommendation #3) and to eliminate any State-specific requirements for display of additional identifiers on the power unit.
5. Consensus should be sought for a standard, North American, commercial vehicle license plate. This plate number could become the vehicle-specific identifier described in recommendation #2. The plate should be designed for maximum readability by OCR systems.

Motor Carrier Acceptance:

1. A stakeholder forum should be established to document the specific concerns of the motor carrier community and to provide guidance for the FHWA and State agencies in implementing electronic technologies. This forum will be tasked with sorting through the advantages, disadvantages, fears, and concerns, and creating a recommended path for implementation of commercial vehicle identification technologies that will provide maximum benefit for all stakeholders.

APPENDIX A. REQUEST FOR INFORMATION (RFI)

The Federal Highway Administration is intimately familiar with both the capabilities and the limitations of transponder-based identification systems. While these systems are extremely reliable for identifying transponder-equipped vehicles, they are inherently limited due to the small proportion of trucks that currently have transponders. Therefore, while continuing the effort to expand and improve transponder-based systems, FHWA is also focusing on the evaluation and implementation of non-transponder-based identification systems.

As such, a Roadside Identification Feasibility Study is being conducted by the Kentucky Transportation Center at the University of Kentucky on behalf of FHWA. The first step of this study is to identify automated, non-intrusive methods of commercial vehicle identification for both high and slow speed applications. If you have developed or are aware of systems that may be used for this application, you are invited to respond to this RFI.

Please include in your response complete contact information and technical and cost information describing the technology. Also explain the degree to which the technology has been deployed. Is the technology still under development or has it been fully deployed? If it has been deployed, where and for what applications? What has been the success of the technology to this point?

All responses should be directed to Jennifer Walton by November 30, 1998 at:

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176 Oliver H. Raymond Building
Lexington, KY 40506-0281
Phone (606) 257-4513 x256
Fax (606) 257-1815
Email jwalton@engr.uky.edu

APPENDIX B. INTERVIEW FORM AND SURVEY RESULTS

Date _____

Conducted by _____

Interview

“OK, first let me verify some information about you:”

Name: _____ Title/Position: _____

Organization: _____

“Now, let’s talk about fixed weigh stations.” (skip this if they have none)

1. With regard to weight checking at fixed weigh stations, do you weigh every truck that comes through, or a sampling of trucks?

every truck 31 sampling 11 other _____

comment _____

2. Do you weigh every truck on a static scale, or are trucks sorted using weigh-in-motion?

all on static 15 sorted on WIM 4 some of each 21

other/comment _____

3. Do you have any weigh stations that screen trucks on the mainline?

No 24 Yes 18

3.a. (If yes) How many sites do mainline screening? AZ - 5, AR - 2, CA - 21, CO - 2, FL - 6, GA - 6, ID - 1, IL - 1, KY -4, MI - 2, MT - 1, NM - 5, OH - 2, OR - 6, TN -7, UT - 2, WA - 2, WY -3

3.b. (If yes) How are trucks identified on the mainline?

Transponders 18 Other _____

Comments _____

3.c. (If yes) Do these sites include mainline weigh-in-motion?

No 6 Yes 12 (at least some sites)

Comments _____

4. With regard to safety checking, is there any kind of safety check that is performed on every truck that passes through the weigh station?

No 25 Yes 15

4.a. (If yes) What kind of check?

Safety inspection 1 Visual check 14 Other _____

comment _____

5. Of the trucks that pass through the weigh station, approximately what percentage are inspected for safety?

Less than 1% 10 Other % (fill in) _____ Don't know 15

Comment (1-5%) - 11, (6-10%) - 2, (11-25%) - 1, (100%) - 1

6. How do enforcement personnel select which trucks will be inspected? (check all that apply)

Random 32 Visual clues 37 Experience with carrier 15

Other 3

Comment _____

7. Do the enforcement personnel make use of any identifying information on the truck in selecting which trucks to inspect? (for example, Company name, USDOT number, license plate number, etc.)

No 13 Yes 28 Specify which: _____

Comment _____

7a. (If yes) How/where is this information read, and how is it used?

Read: USDOT, License plate, Carrier Name, CVSA Sticker, Others

Used: Manually (visual check) and/or automated (ISS)

Comment Iowa has used license plate readers.

8. From the standpoint of safety enforcement, would you see any value in a system that could automatically identify a vehicle as it approached a weigh station? By "identify" we mean to read the license plate number, company name, USDOT number, Vehicle Identification Number, or some other identifier.)

No 2 Yes 39

Comment _____

8a. (If yes) How would such information be useful? save time, help to identify trucks quickly, help to target "problem" carriers, clear safe trucks expeditiously, more efficient use of time for officers, and prevent backups on the highway, etc.

8b. Which identifier would be the best to use?

License plate # 14 USDOT # 27 Company name 6

Vehicle ID # 3 Other 7 (3 of these were the ICC #)

Comment _____

9. From the standpoint of safety enforcement, would you see any value in a system that could automatically identify the driver of a vehicle as it approached a weigh station?

No 4 Yes 36

9a. (If yes) How would such information be useful? To identify suspended or

revoked licenses, for driver awareness and drug/alcohol usage, to check driver qualifications and track driving history, probably not feasible, etc.

OK, now let's turn from safety checking to credentials checking. By "credentials," we mean registration, taxes, insurance, operating authority, etc.

10. With regard to credentials checking, is there any kind of credentials check that is performed on every truck that passes through the weigh station?

No 27 Yes 14

10a. (If yes) What kind of check?

Look at Paperwork 3 Other 2 Visual 9 _____
comment _____

11. Of the trucks that pass through the weigh station, approximately what percentage are checked for proper credentials?

Less than 1% 1 Other % (fill in) (1-5%) - 8, (6-30%) - 5, (31-70%) - 3, (100%) - 5 Don't know 19

Comment _____

12. How do enforcement personnel select which trucks will be checked for credentials? (check all that apply)

Random 14 Visual clues 27 Experience with carrier 12
Other 14

Comment _____

13. Do the enforcement personnel make use of any identifying information on the truck in selecting which trucks to check? (for example, Company name, USDOT number, license plate number, etc.)

No 13 Yes 27 Specify which: _____

Comment _____

13a. (If yes) How/where is this information read, and how is it used?

Read: USDOT, License plate, ICC, VIN, Carrier name, and others

Used: Manually (visual check), ISS, or state registration databases

Comment: _____

14. From the standpoint of credentials enforcement, would you see any value in a system that could automatically identify a vehicle as it approached a weigh station? By "identify" we mean to read the license plate number, company name, USDOT number, Vehicle Identification Number, or some other identifier.)

No 1 Yes 40

Comment _____

14a. (If yes) How would such information be useful? better concentration on "problem" carriers, save time for good carriers, more efficient use of officer's time, reduction in paper sorting, etc.

14b. Which identifier would be the best to use?

License plate # 15 USDOT # 20 Company name 2

Vehicle ID # 6 Other 5

Comment _____

OK. We're finished talking about fixed weigh stations. Let's talk about mobile enforcement. This could include any enforcement activities that don't take place at a fixed weigh station.

15. What kinds of mobile enforcement activities are conducted in your state?

Temporary roadside locations 41 Roving patrols 40

Enforcement at trucker facility 2

Other 1

Comments _____

16. How do mobile enforcement personnel decide which trucks to stop and check?

Visual check -37, all trucks - 15, random selection - 13, based on experience (or lack of experience) with carrier - 11, and other - 2

17. Do mobile enforcement personnel make use of any identifying information from the truck in deciding which truck to stop and check? (for example, Company name, USDOT number, license plate number, etc.)

No 20 Yes 24 Specify which: _____

Comment _____

17a. (If yes) How/where is this information read, and how is it used?

Read: USDOT, Carrier name, License plate, VIN, Unit #

Used: Manually (visual check), radio check of license plate, ISS

Comment _____

18. When a truck is stopped by mobile enforcement personnel for a credentials and/or safety check, do the enforcement personnel make use of any identifying information on the truck in checking the safety or credentials?

No 6 Yes 33 Specify which: _____

18a. (If yes) How is this information read, and how is it used?
Read: License plate, USDOT, Carrier name, VIN, Others
Used: Manually (visual check), radio check of license plate, ISS
Comment _____

19. From the standpoint of mobile enforcement, would you see any value in a system that could automatically identify a vehicle on the road or at the roadside? By “identify” we mean to read the license plate number, company name, USDOT number, Vehicle Identification Number, or some other identifier.)

No 4 Yes 40

Comment _____

19a. (If yes) How would such information be useful? Improve efficiency of officer, save time, help target “problem” carriers, etc.

19b. Which identifier would be the best to use?

License plate # 8 USDOT # 5 Company name 9

Vehicle ID # 1 Other 2

Comment _____

20. From the standpoint of mobile enforcement, would you see any value in a system that could automatically identify the driver of a vehicle on the road or at the roadside?

No 9 Yes 35

20a. (If yes) How would such information be useful? Find the unqualified drivers at these locations, possibly improve safety for the officer

That concludes the specific questions. Now I just have two general questions:

21. Are there any other issues or concerns that we should be aware of regarding roadside identification of commercial vehicles?

Technology is good, but doesn’t replace the officer; still need to watch vehicles closely; need a North American system that would identify vehicles originating in Canada and Mexico; when owner/operators change companies, the USDOT changes; etc.

22. Do you have anything to add?

Sources of funding may be an issue; need interoperability among these systems; need to identify intrastate carriers also; motor carrier industry must be receptive to this technology; CVISN needs to be deployed nationally; do not want total reliance on an automated system - the officer is very important; etc.

APPENDIX C. STATE CONTACT INFORMATION LIST

State	Contact Name	Organization
Alabama	James R. "Randy" Braden	Alabama Department of Transportation
	Lt. Michael Hulak	Alabama Department of Public Safety
Alaska	David Howard	Alaska Department of Transportation and Public Facilities
Arizona	Carlton Hill	Arizona Department of Transportation
Arkansas	Thomas Black	Arkansas State Highway and Transportation Department
	Cpt. George Koffman	Arkansas Highway Police
California	John Van Berkel	California Department of Transportation
Colorado	R.J. Hicks	Colorado Department of Revenue
Delaware	Lt. Bob Yonker	Delaware State Police
Florida	Sgt. Kenny Morris	Florida Department of Transportation
Georgia	Jerry Gossett	Georgia Department of Transportation
	Lucia Ramey	Georgia Public Service Commission
Hawaii	Alex Kaonohi	Hawaii Department of Transportation
Idaho	Alan Frew	Idaho Department of Transportation
Illinois	Dave Johnson	Illinois Department of Transportation
	Rich Telford	Illinois Department of Transportation
Indiana	1st Sgt. James M. Addison	Indiana State Police
Iowa	Cpt. Dave Lorenzen	Iowa Department of Transportation
Kansas	Tony Stewart	Kansas Highway Patrol
Kentucky	Mj. David Herald	Kentucky Transportation Cabinet
Louisiana	James Norman	Louisiana Department of Transportation and Development
	Mj. Mac Linton	Louisiana Department of Transportation and Development
	Robin Paige	Louisiana Public Service Commission
Maine	Lt. Bruce Dow	Maine State Police
Maryland	Sgt. Frau Phelps	Maryland State Police
	Cpt. Guy Guyton	Maryland State Police
	Roger Carriker	Maryland Department of Transportation
Massachusetts	Cpt. Gary Burns	Massachusetts State Police
Michigan	Cpt. Robert Powers	Michigan State Police
Missouri	Gary Steinmetz	Missouri State Highway Patrol
	R.D. Smith	Missouri State Highway Patrol
Montana	Gary Martin	Montana Department of Transportation
Nebraska	Doug Donscheski	Nebraska State Patrol
Nevada	Sgt. Roy Baughman	Nevada Highway Patrol
New Hampshire	Sgt. Wayne Peasley	New Hampshire State Police
New Jersey	Sgt. Joseph Drinkhouse	New Jersey State Police
New Mexico	Gary Trujillo	New Mexico Department of Public Safety
State	Contact Name	Organization

New York	Norm Schneider	New York State Department of Transportation
North Carolina	Cpt. Gordon Zeigler	North Carolina Division of Motor Vehicles
North Dakota	Curtiss Mayhew	North Dakota Highway Patrol
Ohio	Sgt. Skip Dodd	Ohio State Highway Patrol
Oklahoma	Cpt. Bill Hughes	Oklahoma Highway Patrol
	Steve Smith	Oklahoma Tax Commission
Oregon	Steve Johnston	Oregon Department of Transportation
Pennsylvania	Fred Juba	Pennsylvania Department of Transportation
Rhode Island	Bob Farnum	Rhode Island State Police
South Carolina	Cpt. Anna Amos	South Carolina Transport Police
South Dakota	Cpt. Myron Rau	South Dakota Highway Patrol
Tennessee	Cpt. John Williams	Tennessee Department of Safety
Texas	Mj. Lester Mills	Texas Department of Public Safety
Utah	Richard Ollerton	Utah Department of Transportation
Vermont	Sgt. Guy Welch	Vermont Agency of Transportation
Virginia	Lt. Herbert B. Bridges	Virginia State Police
Washington	Tim Erickson	Washington Department of Transportation
Wisconsin	Lt. Sandy Huxtable	Wisconsin State Patrol
Wyoming	Cpt. L. Steve Gerard	Wyoming Highway Patrol

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APPENDIX E. TECHNOLOGY INFORMATIONAL SHEETS

Technology: Optical Character Recognition		Automation: Automatic	
Description: Optical character recognition is the automatic interpretation of human-readable characters		Performance Specifications: Max Read Range: 75-100 feet Max Speed: <90 mph	
Components: 1) Illuminator 2) Trigger 3) Cameras 4) CPU 5) Character Recognition Engine 6) Storage/Transmission System <div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 0 auto;">On-Vehicle Equipment: N/A</div>		Portable: Yes (Extensive training required)	Multiple Lane Capability: No
		Standards: No	Availability: COTS by 35+ Vendors
Level of Maintenance: Reports Vary (Vendors report moderate to light levels of maintenance, including: cleaning of lights, triggers, cameras, and hard drive space monthly. Some states have reported extensive maintenance.)		Equipment Cost: \$40,000 - \$50,000 (All Equipment)	Life Span of Equipment: 7 - 9 years
Areas of Concern: 1) weather related problems 2) camera adjustments 3) location/condition of identifiers 4) site geometrics and requirements 5) data transfer and presentation problems 6) end-user integration 7) number of vendors		Technology Forecast: 1) Faster processing 2) "Standardization"/changes to plate design and syntax 3) All digital cameras 4) Enhanced software and digitizer 5) Improvements to the illuminator	
Applications of the Technology: 1) Toll (free-flow and plaza) collection and enforcement 2) Vehicular law enforcement 3) Secure access control 4) Commercial Vehicle Operations 5) Border crossings 6) Travel time & O/D studies 7) Shipping container tracking 8) Emissions testing 9) Car park management		Potential Vendors: Adaptive Recognition, AITEK, Alphatech, AutoVu Technologies, Belgian Advanced Technology, Blaze Imaging, Codic, Computer Recognition Systems, Electronic Control Mesure, Elettronica Santerno, ELIOP Trafico, Fraunhofer-Institute, Hi-Tech Solutions, Lockheed Martin IMS, MAZ Hamburg, Micro Design, Monitron International, Neuroteknologija, Non-Cooperative Target Recognition, OMRON, Optasia Systems, Perceptics, Pulnix America, R&H Systems, Racal Messenger, R.B. TEC, Redflex Traffic Systems, Rossi, SECOM, Siemens, Tecnologias de Reconocimiento, Telematica, Telstra, Transcore, VECON, Visual Image Dynamics, Zamir Recognition Systems	
Commercial Vehicle Identification Applications: Iowa, Minnesota, Wisconsin, California, Oregon, Colorado, Indiana <div style="border: 1px solid black; padding: 2px;">Evaluations: 1) Smith, Robert L. and Huang, Wen-Jing. "MN/WI Automatic Out-of-Service Verification Operational Test Evaluation." June 1997. 2) Walton, Jennifer R. and Crabtree, Joseph D. "Registration Violations and the Use of Optical Character Recognition Technology at Kentucky Weigh Stations." December 1998.</div>			
Information Provided By: Electro-Optical Technologies (Lee J. Nelson), Perceptics (Roger Leach), Lasercraft (Jim Wilkie), Transformation Systems (Jeff Woodson), Fornix Information Technologies (www.fornix.com), VECON (www.cs.ust.hk/faculty/cmlee/vecon.html), Optasia Systems (www.singapore.com/optasia/imps.htm), ETTM on the Web (www.ettm.com/ves.htm), and SAIC (Richard Doering).			

Technology: RFID - Inductive (100-500 kHz)		Automation: Automatic	
Description: Radio frequency identification relies on electromagnetic waves between a transponder and a reader for automatic identification. With this system, the low frequency transponder is typically powered by the reader's magnetic field.		Performance Specifications: Max Read Range: 6 - 20 feet Max Speed: 25 mph	
Components: 1) Reader 2) Loop Antenna 3) Transponder 4) CPU <div style="border: 1px solid black; padding: 5px; margin-top: 10px; width: fit-content;"> On-Vehicle Equipment: Transponder </div>	Portable: Yes	Multiple Lane Capability: No	
	Standards: No	Availability: COTS, several vendors	
Level of Maintenance: Light to Moderate (The pavement antenna requires moderate levels of maintenance while the electronics require only light maintenance.)		Equipment Cost: \$4000-\$10000 per Reader -\$20 per Transponder	Life Span of Equipment: Passive transponder: 10 - 15 years
Areas of Concern: 1) Installation of the transponder 2) Loss of transponder 3) Low frequency systems not as reliable as high frequency 4) Maintenance of transponder registry and issuance of unique transponder numbers 5) Electromagnetic noise interference 6) Interoperability among systems		Technology Forecast: This technology is fully mature and limited by slow data rate.	
Applications of the Technology: 1) Access Control 2) Animal Identification 3) Inventory Control 4) Slow-speed commercial vehicle identification		Potential Vendors: Texas Instruments (TIRIS) Motorola Indalla	
Commercial Vehicle Identification Applications: Unknown <div style="border: 1px solid black; padding: 5px; margin-top: 10px; width: fit-content;"> Evaluations: Unknown </div>			
Information Provided By: Transponder News, SAIC (Richard Doering), TIRIS (www.ti.com/mc/docs/tiris/docs/index.htm), Motorola Indalla (www.mot.com/LMPS/Indalla/)			

Technology: RFID - Electric Coupling (900 MHz)	Automation: Automatic	
Description: This RFID system relies on the electric propagation properties of radio communication to convey energy and data from the reader to the transponder and data from the transponder to the reader.	Performance Specifications: Max Read Range: 300 feet Max Speed: 120 mph	
Components: 1) Reader 2) Antenna 3) Transponder 4) CPU <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> On-Vehicle Equipment: Transponder </div>	Portable: No <i>(Portable readers have been tested and deployed on a small scale.)</i>	Multiple Lane Capability: Yes
Level of Maintenance: Light to moderate <i>(Reported maintenance is light for the transponder and light to moderate for the other equipment.)</i>	Equipment Cost: \$10,000-15,000 per Reader \$20-60 per Transponder	Life Span of Equipment: 10-15 yrs for Reader 4.5-8 yrs for Active Transponder
Areas of Concern: 1) Compatibility and interoperability with other systems 2) Maintenance of transponder registry and issuance of unique transponder numbers 3) Data integrity 4) Institutional interoperability	Technology Forecast: 1) Increased frequency to 5.85-5.925 GHz 2) Longer read ranges 3) Faster data transfer rates	
Applications of the Technology: 1) Toll Collection and Enforcement 2) Commercial Vehicle Operations 3) Border Crossings 4) Intermodal Freight Identification 5) Access Control	Potential Vendors: Amtech, Bosch, Cegelec CGA, CS Route, Denso, Mark IV, MHI, MicroDesign, MobiTrace, Raytheon, Saab-Combitech, SAIC, SIRIT (formerly Texas Instruments)	
Commercial Vehicle Identification Applications: Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Illinois, Kentucky, Michigan, Mississippi, Montana, New Mexico, New York, Ohio, Ontario, Oregon, Tennessee, Utah, Washington, Wyoming Evaluations: "Evaluation Report: The Advantage I-75 Mainline Automated Clearance System." Draft Executive Summary. University of Kentucky, Kentucky Transportation Center, March 1999.		
Information Provided By: Mark IV (Paul Manuel), Raytheon (Loren Jonkey), Advantage CVO (Joe Crabtree and David Hunsucker), SAIC (Richard Doering)		

Technology: RFID - Doppler Shifting (35 GHz)		Automation: Automatic	
Description: This RFID system utilizes a concept of "electronic" Doppler shifting to generate a frequency shifted signal in response to an interrogation signal.		Performance Specifications: Max Read Range: 330+ feet Max Speed: virtually limitless	
Components: 1) Transmitter 2) Receiver 3) Transponder 4) CPU <div style="border: 1px solid black; padding: 2px; display: inline-block;">On-Vehicle Equipment: Transponder</div>	Portable: Yes	Multiple Lane Capability: Yes	
	Standards: No	Availability: To be determined	
Level of Maintenance: Light to None <i>(Only vendor reported maintenance is available. Prior use of this technology is classified information.)</i>		Equipment Cost: Unknown for Reader \$20-300 per Transponder	Life Span of Equipment: 1+ yrs for Transponder
Areas of Concern: 1) Only one vendor 2) Availability of the technology is uncertain 3) Never used on commercial vehicles 4) Maintenance of a transponder registry and issuance of unique transponder numbers		Technology Forecast: 1) Migration into high security applications	
Applications of the Technology: 1) Classified government programs involving vehicle identification		Potential Vendors: APTI, Inc.	
Commercial Vehicle Identification Applications: None <div style="border: 1px solid black; padding: 2px; display: inline-block;">Evaluations: None</div>			
Information Provided By: Schaffer Corporation (Bill McDonald)			

Technology: Barcode		Automation: Automatic	
Description: A barcode label is illuminated by an infrared or visible laser. The dark bars on the label absorb the light and the spaces reflect it back into the reader. This pattern is then decoded using algorithms.		Performance Specifications: Max Read Range: 2 - 6 feet Max Speed: 30 mph	
Components: 1) Barcode label 2) Reader 3) Storage/ transmission system <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;">On-Vehicle Equipment: Barcode Label</div>	Portable: No	Multiple Lane Capability: No	
	Standards: None	Availability: COTS, at least 3 vendors	
Level of Maintenance: Light <i>(Reported maintenance includes cleaning of the glass on the face plate of the reader.)</i>	Equipment Cost: ~\$5000 per Reader \$2- \$4 per Barcode label	Life Span of Equipment: 2-3 yrs. for Barcode Label	
Areas of Concern: 1) Ease of forging the barcode label 2) Label's sensitivity to weather and dirt	Technology Forecast: Technology is mature		
Applications of the Technology: 1) Vehicle access control 2) Toll collection 3) Railcar identification	Potential Vendors: Accu-sort, Barcode Automation, Industrial Scan		
Commercial Vehicle Identification Applications: Florida <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;">Evaluations: None</div>			
Information Provided By: Automatic ID News, Barcode Automation (Doug Jarrett), Bishop Manor Apartments (Cindy Robertson), Heron Bay Apartments (Patty Smolka)			

Technology: Image Capture		Automation: Manual	
Description: Image capture is the process of obtaining human-readable characters for identification purposes		Performance Specifications: Max Read Range: 200-250 feet Max Speed: 60-80 mph	
Components: 1) Trigger 2) Illuminator 3) Camera(s) 4) CPU 5) Storage/transmission system <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;">On-Vehicle Equipment: N/A</div>	Portable: Yes <i>(Extensive training required)</i>	Multiple Lane Capability: No	
	Standards: Yes <i>(Analog and digital image formats)</i>	Availability: COTS, hundreds of suppliers	
Level of Maintenance: Light to moderate <i>(Reported Maintenance involves monthly cleaning of the cameras, lighting, triggers, and hard drive space.)</i>		Equipment Cost: \$5000-\$40,000 All equipment	Life Span of Equipment: 6 - 9 yrs
Areas of Concern: 1) Negatively affected by adverse weather conditions and harsh roadside environment 2) Lack of specific national standards for the location of identifying information		Technology Forecast: 1) Faster processing units 2) All digital cameras 3) Improved illuminators	
Applications of the Technology: 1) Vehicular law enforcement 2) Crash testing analysis 3) Commercial vehicle operations surveys 4) Access control 5) Commercial parking and revenue control		Potential Vendors: Hundreds of Suppliers	
Commercial Vehicle Identification Applications: None currently, Kentucky is deploying a video imaging system to capture the USDOT number this year. <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;">Evaluations: None</div>			
Information Provided By: Lasercraft (Jim Wilkie), Integrated Sensors (John Retelle and John Capelli), Transformation Systems (Jeff Woodson), "Video Enforcement of HOV Lanes: Field Test Results for the I-30 HOV Lane in Dallas" (Shawn Turner, Texas Transportation Institute)			

Technology: Voice Recognition		Automation: Manual	
Description: Voice recognition technology converts human speech into electrical signals and transforms these signals into coding patterns with assigned meanings.		Performance Specifications: Max Read Range: Varies Max speed: Varies	
Components: 1) Microphone headset 2) Voice recognition sound card 3) CPU <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;">On-Vehicle Equipment: N/A</div>		Portable: Yes <i>(Software is currently not available.)</i>	Multiple Lane Capability: No
		Standards: No	Availability: COTS, many suppliers
Level of Maintenance: Light to None		Equipment Cost: <\$1000 <i>(All equipment and installation)</i>	Life Span of Equipment:
Areas of Concern: 1) New Digital Signal Processing card needed 2) Noise cancellation stick-microphone needed 3) Upgrade needed to 32-bit code built around ISS-2		Technology Forecast: Technology is mature.	
Applications of the Technology: 1) Identifying damage on railway cars 2) Commercial vehicle identification 3) Commercial Vehicle Inspection		Potential Vendors: Signal Processing Systems	
Commercial Vehicle Identification Applications: Nebraska, Washington <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> Evaluations: Signal Processing Systems. "Nebraska Phase III - Aspen Speaker-Dependent Speech Recognition Final Report". </div>			
Information Provided By: Office of Motor Carriers and Highway Safety (Mike Blevins), Nebraska State Patrol (Bryce Wellnitz), Signal Processing Systems (Frank Blair), "Nebraska Phase III - Aspen Speaker-Dependent Speech Recognition Final Report" by Signal Processing Systems			

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